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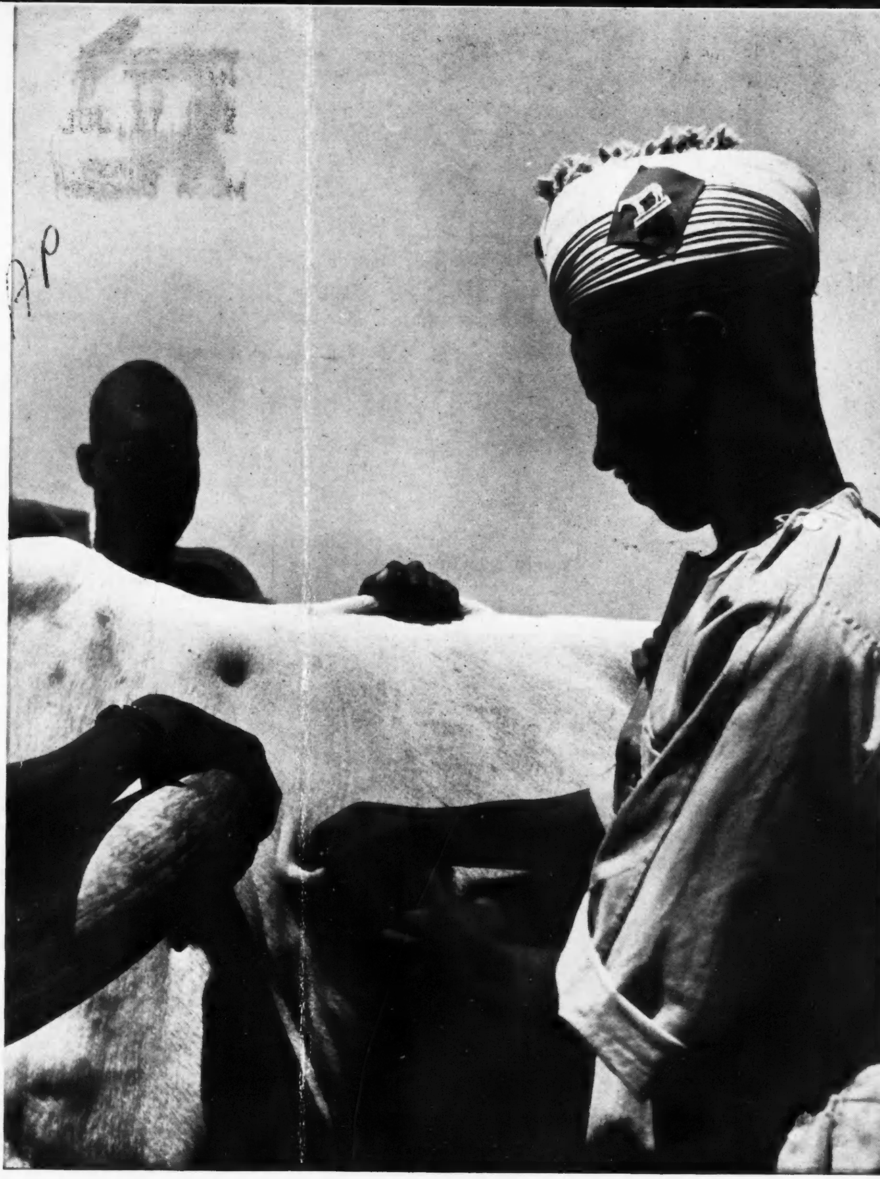

A cow being injected with Antrycide

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THE MAGAZINE OF SCIENTIFIC PROGRESS

July, 1952 Vol. XIII. No. 7

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The Progress of Science

The Demand for Scientists

WHEN World War II ended Britain found herself with an army of about 55,000 scientists, and the prospect that each year of the reconstruction period would see an increase in the excess of demand over the supply of scientific manpower. The Barlow Committee on Scientific Manpower, which presented its report in 1946, predicted a deficit of ten to fifteen thousand scientists by 1950 unless drastic measures were taken to recruit and train more personnel. By 1955 the deficit would rise to about 26,000. The committee came to the conclusion that the universities and technical colleges would have to produce 5000 science graduates a year if a balance between supply and demand was to be reached by 1955, which meant a doubling of the output of science graduates within a decade.

The present situation has now been reviewed by the Zuckerman Committee, which was appointed in December 1950 by the Advisory Council on Scientific Policy "to study the future needs of scientific and technological manpower for employment both at home and abroad". This committee has now reported, and its report makes up the whole of the *Fifth Annual Report of the Advisory Council on Scientific Policy* (1951–52), published by H.M.S.O., Cmd. 8561, price 6*d*. Its principal conclusion is that there is likely to be a continuing shortage of almost all kinds of scientists,* and it calls for further expansion of facilities for scientific education. Special efforts need to be made, says the committee, to increase the supply of chemists, chemical engineers, electrical engineers, mechanical engineers and physicists. The supply of geologists, civil engineers and metallurgists are apparently equal to the demand at present.

The committee reports that there is some unemployment of men "trained primarily in the basic biological sciences", adding that there is simultaneously a shortage of specialist biologists such as insect physiologists and mycologists. The committee is inclined to be pessimistic about the prospects for biologists, and goes so far as to suggest that the universities ought to consider revision of the general curriculum, hinting that the introduction of more chemistry and physics might equip biology graduates for a wider range of employment than is now open to them.

* The report uses the word 'scientist' to describe any person "trained in fundamental or applied science (which includes engineering)".

That technical colleges could be geared to increase their output of science graduates relatively quickly has been the official Ministry of Education view for some time, and the Zuckerman Committee comes out in support of the Ministry's opinion. It suggests that a few colleges could be selected for special development with the immediate aim of turning out more men trained to graduate level.* It is emphasised that technical colleges could only produce a fraction of the extra science graduates that Britain needs. The major contribution to the solution of the problem must be made by the universities, and the Zuckerman Committee accepts this as axiomatic. It should be noted that our universities have already doubled their output of scientists, as recommended by the Barlow Committee; "their standards have not declined as a result of the rapid expansion", comments the report, which may help to resolve some of the doubts that arise when one contemplates further expansion of the science faculties of our universities.

Possibly the most contentious passage in the Zuckerman Committee's report is the one which accuses public schools "which we define here as those schools, mostly boarding schools, to which boys go at about the age of thirteen from preparatory schools where they have usually had a fair mathematical but little or no science teaching" of failing

* On June 11 (the first day of a two-day debate in the House of Lords on Science and Industry) Lord Woolton, who as Lord President of the Council is the member of the Government with the major responsibility for civilian scientific matters, stated that details of the Government's proposals "for improving financial assistance . . . for [technical] colleges and courses will shortly be announced by the Ministry of Education". In the same debate (which we shall discuss in next month's issue) he turned down the proposal for a non-teaching award-making 'Royal College of Technology', which was recommended by the 1950 report of the Advisory Council on Education for Industry and Commerce appointed by the Education Ministry. Lord Woolton said that the Government favoured instead the creation of at least one institution devoted predominantly to the teaching and study of the various forms of technology. Readers will recall that as long ago as last December we stated that this was the policy favoured by the Government.

to encourage students with a scientific bent. This passage we quote in full, mainly because we feel sure that there is another side to this particular problem, and we hope that someone will come forward to answer the Committee's criticisms. As few schoolmasters are even likely to see this report, here is the relevant extract:

"It seems clear that science does not attract as many public school boys of outstanding ability as is desirable in the present national interest, or as would be attracted if circumstances were different. In saying this we recognise that science certainly occupies a position of far greater prominence and respect in these schools than it did some years ago, and that probably about half the boys in the sixth forms of today specialise in science. At the same time we have to recognise that the interest of the ablest boys is often attracted to the subjects taught by the more outstanding masters, and that in public schools this is more likely to operate in favour of subjects other than science. In some schools there may also be other influences which counteract the attractions of science. Among these are the traditional emphasis on non-scientific subjects in the curriculum which most boys, in particular the ablest boys, follow for the first few years; the attractions of the study of the humanities at Oxford and Cambridge, including the opportunity for the winning of scholarships leading to such study; and sometimes, although far less today than before, the adverse attitude of many parents of public school boys to the careers to which a scientific education is likely to lead, in particular to technical posts in industry. Essentially there is an insufficient appreciation of the contribution that science makes to a liberal education, and a lack of awareness of the great opportunities for scientific, and especially engineering, training that are available in universities other than Oxford and Cambridge. Without some change in these influences and attitudes, we do not think it likely that the public schools will play their proper part in sending a reasonable proportion of their best boys forward for a scientific and, in particular, a technological education."

After this sharp criticism we are suprised to find that the Committee is vague when it comes to discussing the need to ensure an adequate supply of good science teachers to schools. After stating that considerable increase in the rate of recruitment (roughly from some 800–900 to some 1200–1300 a year in England and Wales) is needed if present deficiencies are to be made good, and to provide for an increase in the number of grammar school pupils the report says, "It may become necessary to take special measures to increase the numbers of science teachers in the schools even at the expense of what may appear to be more immediately important tasks." Top priority for science teaching was also demanded by the Barlow Committee, but the demand was never met. Surely the Advisory Council could go a great deal farther than simply expressing a pious hope which will have little impact on the government department concerned? As Lord Samuel has said, we are on the eve of very important decisions which will determine, perhaps for a generation, the trend of development of our national system of education. The Government cannot indefinitely defer these matters by promising "active consideration"; two years at least have been wasted by such consideration of the needs of higher technological education. What is required is some swift deliberation, imbued by wisdom and leading to a sane and workable policy which government departments can understand and implement.

Phosphorus Outside the Laboratory

PHOSPHORUS is one of the magic words, and one which evokes vivid memories of the first day one watched the chemistry master extract a small piece of yellowish wax from the jar in which it was carefully preserved under water, and the way in which it proceeded to smoke and eventually to burst into flame all on its own. Only Marlowe can recapture the hold which chemistry fastens on us from that moment:

> Philosophy is odious and obscure;
> Both law and physic are for petty wits;
> Divinity is basest of the three,
> Unpleasant, harsh, contemptible, and vile;
> 'Tis magic, magic, that hath ravished me.

As a common material of commerce, phosphorus belongs to the last hundred years. Its history in this country is virtually that of the Birmingham firm of Albright and Wilson, whose centenary is celebrated by the publication of a memorial volume.* The growth of population with the Industrial Revolution, its concentration in town and factory, and the development of coal-gas as an illuminant forced the development of fire-making equipment handier than flint and tinder. Prometheus bowed to Lucifer, and the match industry, which originally required white phosphorus, arose.

The independent discovery of phosphorus and the first chemical examination of its properties can be attributed to Robert Boyle in 1670 and the importance of his work outweighs that of Brand, the Hamburg alchemist, who is usually given all the credit for discovering this element. Garrick has a couplet:

> In the deep mines of science though Frenchmen may toil,
> Can their strength be compared with Locke, Newton
> and Boyle.

Some strength must have been needed to follow Boyle's own recipe for preparing phosphorus:

> "Took a considerable quantity of human urine that had been for a competent while digested, or putrified, before it was used. The liquor was distilled at a moderate heat . . . until the substance was brought to the consistence of a somewhat thick syrup. This was well incorporated with about thrice its weight of fine white sand, and the mixture put into a strong retort, to which was joined a large receiver, in good part filled with water. Then, the two vessels being carefully luted together, a naked fire was gradually administered for five or six hours . . . the fire was incresed . . . as strong and intense as the furnace (which was not bad) was capable of."

Boyle's preparation sold at fifty shillings an ounce but by 1833 the price to match-makers was down to forty-two shillings a pound. This was the point where Arthur Albright, a

* *100 Years of Phosphorus Making, 1851–1951.* By R. E. Threlfall, published by Albright and Wilson Ltd., Oldbury, 1951, 400 pp. The author is the son of Sir Richard Threlfall, F.R.S., mentioned later in this note.

young Quaker of twenty-nine, came in. He joined the firm of J. & E. Sturge, of Wheeleys Lane, Birmingham, whose name is an honoured one in chemical industry. Albright persuaded them in 1844 to begin the manufacture of phosphorus and in 1850 the site at Oldbury was acquired. Phosphorus production started there in 1851. Three years later the partnership was dissolved, and Albright took over the business of phosphorus manufacture; in that enterprise he was joined in 1856 by J. E. Wilson, who was then only twenty-two years old.

The original method of making phosphorus was to distil a mixture of carbon (in the form of coal or charcoal) and phosphoric acid in clay retorts and this process held the field until the electrothermal process superseded it in the 'nineties. Commercial bone ash contains 27–37% of phosphoric acid as tricalcium phosphate. The bones were first degreased and softened in hydrochloric acid; after treatment with milk of lime the precipitated phosphates were washed, dried and collected. In place of bones, mineral calcium phosphates could be used. Nowadays, the main sources of phosphorus are phosphate rock from Florida and North Africa. (There are no suitable phosphates in the British Isles.) After grinding, the rock phosphate was decomposed with sulphuric acid, this usually being done in large round wooden tubs lined with lead, which were heated with steam and stirred. After about four hours a solution of phosphoric acid could be taken off the insoluble calcium sulphate. This was concentrated by boiling, and mixed with ground coal or charcoal for charging to iron pots in which the mixture was dried. The dry powder was filled into clay retorts, which were closed with a plug into which was inserted a cast-iron swan-neck connecting it with a condenser tube (see Fig. 1). On heating the retorts, phosphorus distilled over and collected in the condensers. Three charges a week were worked, beginning on Monday, Wednesday and Friday mornings, the actual process of distillation taking about sixteen hours. The crude phosphorus after setting into 25–30 lb. blocks was refined with sodium dichromate and sulphuric acid, settled and then cast into wedges or sticks. All operations after the phosphorus is taken out of the condensers—i.e. purifying, handling, stocking, packing and despatching—must take place under water.

The advantage enjoyed by Albright and Wilson in this process was cheap British coal, and points the moral that industrial progress and supremacy are largely dependent on cheap fuel being readily available. From 1850 England ceased to import phosphorus and became increasingly an exporter. The expansion of the industry, however, troubled Arthur Albright, not from any technical standpoint but because of his Quaker principles.

> "With the strongest reasons for believing the very best I possibly could do of the great merit of common phosphorus matches for the millions, I had no right to shut my eyes to the dangers and risks to health and property which attended, and which, after all proper precautions are observed, must ever in degree attend their manufacture and use."

This referred to phosphorus necrosis, or 'phossy jaw'. This rotting of the jaw was recognised by a Viennese physician in 1845 as an occupational disease of match-

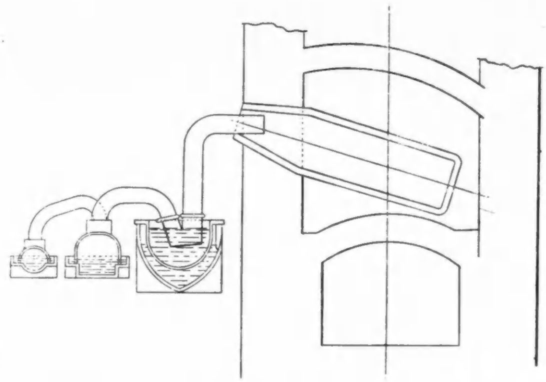

FIG. 1.—The old-style manufacture of phosphorus. Phosphoric acid was reduced by heating it with coal or charcoal. The phosphorus distilled over from the retort and was collected in the water-cooled condensers.

makers, who were drawn from the most necessitous sections of the working class, 'ragged, half-starved, untaught children'. This was the verdict of the Children's Employment Commission in their first report in 1863, when among their witness were 270 under eighteen, 50 under ten, 10 only eight years old, and 5 only six years old. The length of the working day ranged from 12 to 15 hours, night work was usual and meal-times were generally taken in the workrooms, which were full of the poisonous exhalations of white phosphorus.

Amorphous phosphorus, which is non-poisonous, appeared to offer a solution of this problem, but it was many years before it was solved. Arthur Albright bought a patent for preparing amorphous phosphorus from Prof. Schrotter of Vienna who had discovered it in 1845 and read a paper on it in 1849 at the second British Association meeting in Birmingham. He improved Schrotter's method, which derived amorphous phosphorus from white phosphorus by heating the latter in a closed pot later fitted with a kind of safety-valve.

The development of the safety-match came later, in fact it was not fully realised until the introduction of phosphorus sesquisulphide in 1899.

Albright exhibited his amorphous phosphorus at the Great Exhibition of 1851, which attracted a great deal of attention and was fully described in the *Cyclopaedia of Useful Arts*. In particular, it attracted two Swedish visitors who took back with them a sample which they made up into experimental matches, only to forget about them until 1855 when they belatedly tested them and found to their surprise that they ignited. This was the beginning of the Swedish Match Corporation. In an attempt to preserve their secret, the Swedes sent an order for a large quantity of phosphorus to Albright, saying it was wanted for a purpose other than the manufacture of matches. The acknowledgment from Albright ran, "Gentlemen: Amorphous phosphorus, in such quantities as stated in your letter, can, to the best of my judgment, only be used for purposes of war. As I, who belong to the Society of Friends, disapprove of war, I beg respectfully to decline your order."

The same scrupulous attitude was to be taken by his son William Arthur in the 1914–18 war. He was educated like his brothers and the Wilsons at Grove House, a Quaker school at Tottenham, which subsequently and successively housed Bancroft's School, an Anglo-German club, a police station and court, a Jewish hospital and a polytechnic under the Middlesex County Council. He was chairman of the Company from 1903 to 1915, and resigned in the latter year because the filling of shells with phosphorus for military purposes (they were needed for laying smoke-screens) was incompatible with his Quaker principles. All dividends from his shares during the war years he gave to a trust for the benefit of the workpeople. His brother, George Stacey, took a double first in Natural Science and was responsible for the turn to scientific research and staffing in the firm. He had a big share in the engagement in 1899 of Richard Threlfall, F.R.S., a pioneer chemical engineer who is the only member of that profession yet mentioned in the *Dictionary of National Biography*.

The range of Threlfall's activities was to be enormous. The highlights of his technological career were: his electrolytic methods of making chlorates, pure zinc and ammonium persulphate; modifications of the phosphorus furnaces; the building of gas-making plant and the installation of large gas engines, together with the measurement of gas and the efficiency of electric generators; carbon tetrachloride and bisulphide; his tunnel for the conversion of acid sodium orthophosphate to the pyrophosphate; the esters of silica; glycerophosphates. All these achievements followed an academic career, which began at Strassburg where he studied under Professors Kundt and Fittig, and continued at Cambridge where he invented the first automatic microtome and was top of the list in both chemistry and physics in the Natural Sciences Tripos. He became a demonstrator at the Cavendish Laboratory with Professor J. J. Thomson, and Professor of Physics at Sydney University, N.S.W. Such was his ability for recognising talent in others that Sir Henry Tizard has stated that Threlfall spotted Rutherford as a 'winner' within ten minutes of his entering the laboratory at Sydney on his way to Cambridge with an 1851 Exhibition.

By the turn of the century the old method of making phosphorus was giving way to the electrothermal (Figs. 2–3). The electric power then needed at Oldbury was generated by means of large gas engines and cost three-eighths of a penny a unit—with rough coal at 8*s*. 3*d*. a ton and fine coal at 5*s*. 7*d*. a ton! The works established by the firm at Niagara rapidly proved competitive because of the cheap hydroelectric power available there. The demands of the 1914–18 war for phosphorus kept the Birmingham plant going, and a new plant was constructed in eighteen months at Wolverhampton. Output rose from two and a quarter million pounds in 1914 to six million in 1918.

The inflated war-time requirements were succeeded by a slump, but by diversification of products, which included phosphorus, a whole new industry was created. Pure phosphates—made from phosphoric acid obtained by burning phosphorus—ousted tartrates for use in bread-making. Calgon, an unusual phosphate which prevents calcium salts from precipitating when soap meets hard water, is known to most people who run a washing machine and is important for softening the water used in boilers. The chlorides of phosphorus (oxychloride, trichloride and pentachloride) are made in large quantities being required in the preparation of such products as tricresyl phosphate (which is used as a plasticiser for many plastics). Phosphoric acid itself is being used in increasing amounts for putting a protective coating on metal prior to painting; this process is applied to car bodies, for instance.

The full story of phosphorus in the recent war has yet to be disclosed. Coloured flares for bombing, markers for air-sea rescue work and tracer bullets are some of the more obvious outlets for this element. A weapon involving phosphorus was Britain's version of the 'Molotov Cocktail'

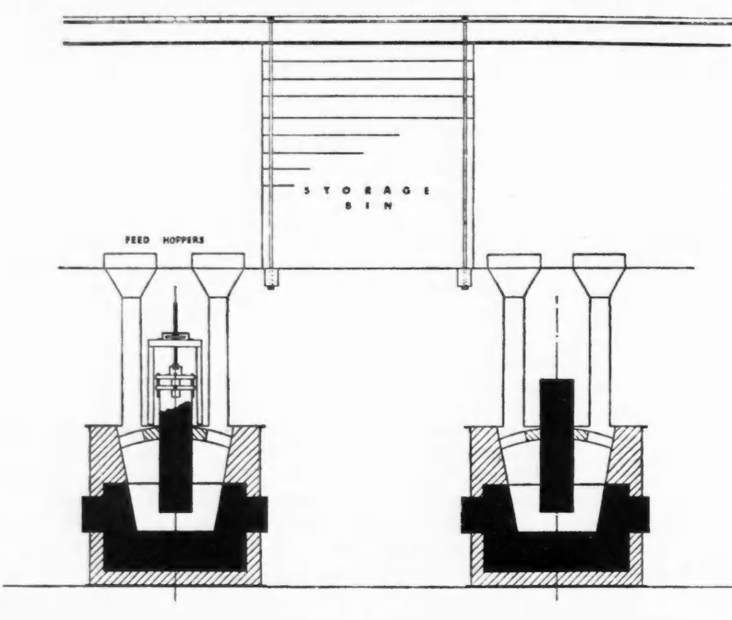

FIG. 2.—This sectional drawing shows the main features of the furnaces first used to make phosphorus at Oldbury by the electrothermal process. A mixture of ground phosphate rock and coke was fed down into the furnace from the hoppers. The electrodes, shown black here, were made from a mixture of anthracite (or coke) and tar. The original electric furnaces at Oldbury had an annual output of 200 tons.

of which seven and a quarter million were made—but never used. Albright and Wilson guaranteed and fulfilled a promise to start production in three weeks of an unwholesome mixture of benzene and a special non-freezing compound of phosphorus in half-pint beer-bottles.

New developments continue to be introduced by the Albright and Wilson team; alginates from seaweed and silicones are among the most recent. Every new chemical produced brings new problems, which is the common lot of the chemical industry. The problems are often unexpected. There was, for instance, the famous case of the 'tomcat' smell which, according to a report, led to the unmerited death of 10,000 cats around Oldbury before it was tracked down to a change that had been made in a process carried out at the factory and put right to the satisfaction of the Alkali Inspector. To outsiders, Oldbury may look dull, but in the last hundred years there can have seldom been a dull moment there!

An Atomic Engine for Ships

LAST DECEMBER we published in "The Progress of Science" a note which was headed: A New Atomic Epoch is Beginning. This note took the line that during 1951 a big advance had been made towards the solving of the really practical problems involved in the harnessing of atomic power. Focus of interest at that time was the new reactor at the Arco Proving Ground in Idaho designed to produce steam capable of driving a 1000-kilowatt generator, and to test the practicability of breeding nuclear fuel. Now it emerges that this work has reached the stage where it is practicable to build an atomic engine for powering submarines. Such an engine is already under construction, and on June 14 President Truman attended the ceremony connected with laying the keel of the submarine which will be powered by that engine. He stated that the vessel's hull had already been built at the Arco Proving Ground, and a full-scale atomic engine was being put into it.

This development will certainly revolutionise naval tactics and strategy, for atomic-powered submarines will be able to travel under water for very long periods; the need to surface at frequent intervals to re-charge batteries is eliminated, while the atomic submarines will have a far greater range as re-fuelling will not have to be carried out so often.

Where the U.S.A. releases quotable statements about the progress made by its Atomic Energy Commission, only faint hints and whispers escape from Harwell and Risley. (The glossy six-shilling Harwell booklet contains practically no new information, and is indeed several years out of date.) But the head of the U.S. Atomic Energy Commission has said that Britain may well produce the first atomic power station, so the silence of our Atomic Energy Directorate must clearly *not* be interpreted as failure to hold our position in the atomic energy race.

Darwinism: The Substance and The Shadow

Two new reprints of *Origin of Species* have recently appeared. The first is the reprint by Watts & Co. of the first edition (1859), with a foreword by Dr. C. D. Darlington. The second is the reprint published by Oxford University

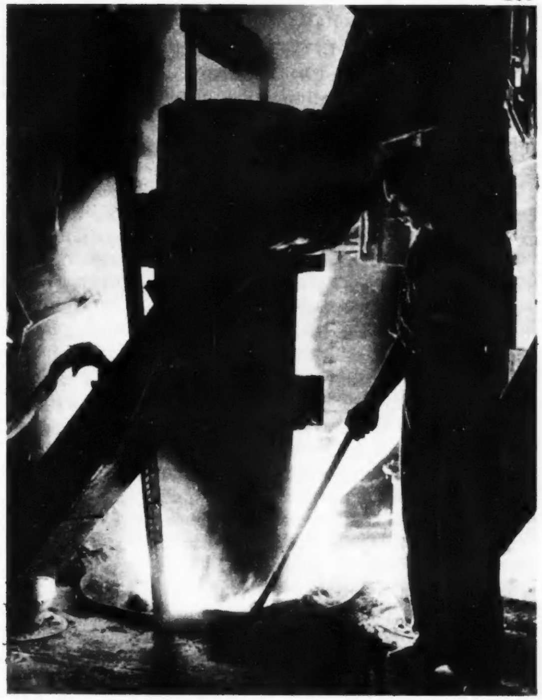

FIG. 3.—The tamping electrode (the central electrode of Fig. 2) in a modern electric furnace for making phosphorus.

Press of the sixth edition, the *final* edition, with a preface by Prof. G. R. de Beer, who is now director of the Natural History Museum at South Kensington.

It was in the spring of 1859 that Mr. John Murray accepted for publication a manuscript of Darwin's entitled *Abstract of an Essay on the Origin of Species and Varieties through Natural Selection.* Darwin addressed his 'abstract of an essay' to the world of science; it was in fact an amplification, a substantiation, of the theory of natural selection originally put forward in the joint paper of Darwin and Wallace which was read to the Linnean Society of London on July 1, 1858, and afterwards published in the Linnean Society's *Journal of Proceedings* (Zoology, Vol. 3, August 20, 1858).

The first edition was sold out on the day of publication —November 24, 1859. Every new edition and every new reprint has met a comparable demand, and *Origin of Species* continues to be a best-seller. Every person who wishes to be thought well-read buys a copy; though one cannot help wondering how many of the people who have bought the book have actually read it. A great many people learn about Darwinism at second hand, relying on some popular digest of Darwin's idea and never going to the fountain head. There are others again who have studied *Origin of Species* reverently—only to come to the conclusion that it is unreadable. Today one meets many professional biologists who boast that they have never been able to finish *Origin of Species*, in much the same way that people can boast about failing to read Tolstoy's *War and Peace* to the end. Yet in the Victorian Age, from 1860

onwards, all educated men read it; it was regarded as belonging not merely to the world of science, but to the whole world: it was read by statesmen, bankers, engineers, poets, philosophers, astronomers, theologians and historians, and the artisans became equally well acquainted with Darwin's ideas after hearing them explained by lecturers like the great T. H. Huxley.

The book was read, and understood: moreover, as Darlington says, "all educated men felt it their duty to express an opinion on the problems discussed by Darwin".

That *Origin of Species* concerned the world of non-biologists is indicated by the fact, brought out in Darlington's preface, that the most serious weakness in Darwins' theory was that discovered by a professor of *engineering*, Prof. Fleming Jenkin of Edinburgh. Prof. Jenkin pointed out, in 1867, that any new variation appearing in one individual would be lost or swamped in later generations when that individual was compelled to cross with others of the old and established type, and its special differences, as Darwin believed, were blended in inheritance and therefore diluted. As Darlington remarks in his preface, "*Nature would never be able to keep any differences to select.*"

Blending inheritance was, of course, a mistaken idea. Mendel's experiments, which started in 1859, proved that genetic characters "persist—they carry on, generation after generation, unblended, untainted, and free for Natural Selection to work upon", to quote Darlington. Unhappily Mendel's theory did not register when it was first published and so long as the particulate nature of genetic factors was not appreciated Prof. Jenkin's fundamental objection to the theory of natural selection could not be answered effectively.

Darwin himself had foreseen the difficulty and had covered himself by saying, in the introduction to the first edition of *Origin of Species*, that "Natural Selection has been the main *but not exclusive* means of modification". In later editions he took refuge behind arguments which were similar to those of Lamarck. Darlington stresses that Darwin's and Wallace's particular claim to originality was the theory of *natural selection*—that nature selected the fittest, in that the fit outbred the unfit because they had a better chance to reproduce than did the unfit. "Darwin was therefore right in his own, his original opinion. And if he had known Mendel's work he need never have hedged", are the words with which Darlington drives home this all-important point. There is thus strong justification for reprinting the *first* edition of *Origin of Species*, for it is this edition in which one finds Darwin's theory "unspoilt by later hesitation, unimpaired by yielding to the trivial and captious critic".

It is one of the supreme ironies in the long history of science that, owing to the general failure to appreciate Mendel's theory, Darwin ended up by having to modify *Origin of Species* to the extent of introducing Lamarckian ideas. It is just those patches of Lamarckianism that have been cultivated by Soviet Russia, and it is these odd irrelevant ideas, which Darwin brought in because he felt a need to circumvent the difficulties which could not be countered so long as the false belief in blending inheritance prevailed, that have been embroidered to produce what Darlington has called "the costume of *Soviet Darwinism*".

Science like other human activities undergoes evolution, and a kind of natural selection weeds out the true theories from the false hypotheses. Darwinism has evolved into what is called 'Neo-Darwinism', into which have been assimilated Mendelism, and also Morgan's work demonstrating that the genetic factors or genes reside in the chromosomes.

The ideas of Darwin, who was elected a corresponding member of the Imperial Academy of Sciences of St. Petersburg during his life, have now become mixed up with the essentially non-scientific teachings of Marx, Lenin and Stalin. Or rather the Russians have appropriated those parts of *Origin of Species* which are taken as *confirmation* of the so-called 'laws of social development' propounded by the three main pillars on which the Soviet creed rests. The result is that what the Communists choose to call Darwinism is used to justify ideas which would most certainly have horrified Darwin.

It was a President of the Soviet Academy of Sciences, the late Sergei Vavilov, who said that "Darwinism has found its second home in the U.S.S.R".* But it is essential to state, lest the reader draw the wrong conclusion from Vavilov's remark, that the Darwinism which the Communists preach is absolutely different from Darwinism as it is understood today outside of Russia. Neo-Darwinism, which incorporates the findings of Mendel and Morgan, is in fact a proscribed doctrine in Russia; the name of Mendel is publicly reviled, and not for any scientific reason, while Morgan suffers the fate of the gene and is ridiculed as "an entity which is contrary to the materialist basis of science". Soviet Darwinism has to be consistent with the policy that "man can remake his crops, his beasts, and even himself", to quote Prof. Eric Ashby. The idea of natural selection must therefore be jettisoned, along with Mendel's law, and the deduction of Morgan, Darlington, Müller, N. I. Vavilov and all other modern geneticists.

It is no accident to find, for instance, that A. G. Morton's new book entitled *Soviet Genetics* does not even include the term 'natural selection' in the index, while this concept, which is the crux of Darwinism, does not seem to be referred to in the text, in spite of the fact that Darwin is mentioned on eight different pages. Having repudiated what Darlington calls "the discoveries of the material basis of heredity, which have removed the need for this patching and darning", which Darwin carried out in later editions of *Origin of Species*, the approved school of Soviet biology has to adopt a Lamarckian creed, a creed favouring "an idealistic force of heredity, too feeble and fluctuating to resist the overpowering influence of a revolutionary environment". Lysenko, for instance, believes that characters produced by the impact of environment, nurture, techniques of cultivation and so on, are inherited by plants and animals. This is a comfortable dogma in one respect: if such inheritance of acquired characters did occur, then the improvement of plants and animals could be achieved rapidly.

In *Soviet Genetics*, Dr. Morton goes so far as to say that Darwin is "more honoured and studied in Russia at the present time than in the country of his birth". Darwin would have been better satisfied with a purely scientific appraisal of his life's work.

* Since this note was originally written, reports from Moscow reveal that this spring the 70th anniversary of Darwin's death was made the occasion for celebrations on a grand scale, at which Lysenko was the main speaker.

A Stone Age Trade Route in East Anglia

E. A. and E. L. RUDGE

For many years there has been much speculation regarding the manner in which our prehistoric ancestors found their way about the country. That they travelled very extensively is abundantly clear, for flint 'workshop floors' and stone artifacts of similar and related cultural types have been discovered in widely distributed areas of Britain. Prior to the Neolithic invasion, primitive man was a hunter and a nomad, wandering on foot in search of his food. Neolithic man introduced the horse and the wheel and the art of agriculture; even so, in his more settled community life there existed the need for travel for trade and barter. Hence, throughout prehistory we may conclude that man acquired the art of surveying and planning his routes across the land according to his needs. Many writers have identified the so-called 'green roads', such as Icknield Way and Peddar Way, with these primitive routes mapped out by early man, but no conclusive evidence linking these 'Ways' with any definite culture had hitherto been forthcoming.

The First 'Milestone'

Three years ago we discovered what may prove to be one of the earliest of these Flint Age tracks to which a probable age and function can be ascribed. Our discovery began with the observation of a large boulder standing on the roadside at the hamlet of Holyfield in Essex, a mile or so north of Waltham Abbey and scarcely twelve miles from the City of London. The boulder (Fig. 2) was pearshaped and obviously weathered and water-worn, about thirty inches high and eighty inches round the base. It rests upon a small shelf of river gravel on a slight rise on the east bank of the river Lea.

But it was the material of the boulder which held our attention, for it was of the strikingly characteristic local rock known as Hertfordshire Conglomerate, or 'Puddingstone'. This name is apt, for it consists of numbers of flint pebbles set in a hard siliceous matrix, like raisins in a pudding. At first we considered it to be a glacial erratic, washed out of the boulder clay from the nearby Epping Upland, but our opinion was changed with the further discovery of four other similar boulders, lying roughly in a line a mile and a half long, leading eastwards from the alluvial plain of the Lea to the crest of the Upland. Two were deeply sunk in soft ground with only a few inches of the tips showing, and the others were hidden in the undergrowth of dense woodlands. It was too much to credit glacial action with the phenomenal coincidence of a line of five puddingstone boulders of similar size leading uphill in this manner, and we considered the possibility of human agency being responsible. Again, if the hand of man had placed them there, it must have been for an important and urgent reason, for the natural rock does not occur within a distance of five miles of the district. Obviously the line suggested that others may lie still farther to the east, and in this way a search began which has produced the extraordinary evidence outlined below.

Prolonged search to the east, in the direction indicated by the Holyfield alignment, eventually led to the discovery of other boulders, every one of which was a puddingstone. All lay in a straggling line leading in a generally eastward direction, and the first indication that we had hit upon a deliberately placed system, marking out a definite track, came with the finding of the Cross Keys Stone, just inside a field opposite the Cross Keys Inn on the Epping to Bishop's Stortford road. This boulder was nearly six miles from our starting-point at Holyfield. It was deeply embedded and disc-shaped, with the narrow edge accurately pointing in the direction of our track. To the east it pointed to Stone Farm, and beyond to the village of Magdalen Laver.

Saxon Churches along the Route

At Magdalen Laver we found the very first real indication of the antiquity of our alignment. A large puddingstone boulder lay under the north wall of the ancient church, resting on the Saxon foundations. For an explanation we turned to church history. In Early Saxon times the Christian missionaries to this country encountered great opposition to the new faith, for the pagan inhabitants clung tenaciously to the worship of stones which they endowed with the personalities of their heathen deities. Pope Gregory was aware of this, and instructed his missionaries by letter, in A.D. 601, to avoid destroying the pagan stones, but to incorporate them in the fabric of the new church. Thus we have to thank Gregory for the preservation not only of the Magdalen Laver Stone, but also for sixteen others of our series found in like manner in association with Saxon churches, and it became a routine to examine the foundations of such churches which fell upon our line.

The Magdalen Laver Stone therefore clearly showed that our alignment existed in pagan times, and that its stones were held in esteem by the Saxon population. To some extent this esteem has persisted to the present time, for we have found that countryfolk as a rule show a curious reluctance to disturb, much less destroy, these ancient stones. Puddingstone holds an especial significance in the minds of rural people, for it, and it alone, is known as 'breeding-stone', 'growing-stone' and 'mother-stone'—names which we have found in use in remote places as far apart as Oxfordshire and Suffolk.

Stone by stone the trail led us eastward through Essex. Sometimes the boulders were four or five to a mile, and sometimes they were missing over gaps of a mile or two. Yet the pattern of the track became very clear. The boulders were originally sighting-stones, usually at irregular intervals upon strategic sites such as hill-slopes or beside the fording-places on the many streams. The track was by no means straight, yet it held to a general easterly direction, clinging to the gravel patches on the low hills and avoiding the claylands of the river valleys. Sometimes the stone would be found in a farmyard, and sometimes by the roadside. Occasionally we found it had been moved from its original site, even by as much as a mile. Always the streams were forded where the banks sloped steeply down and the water

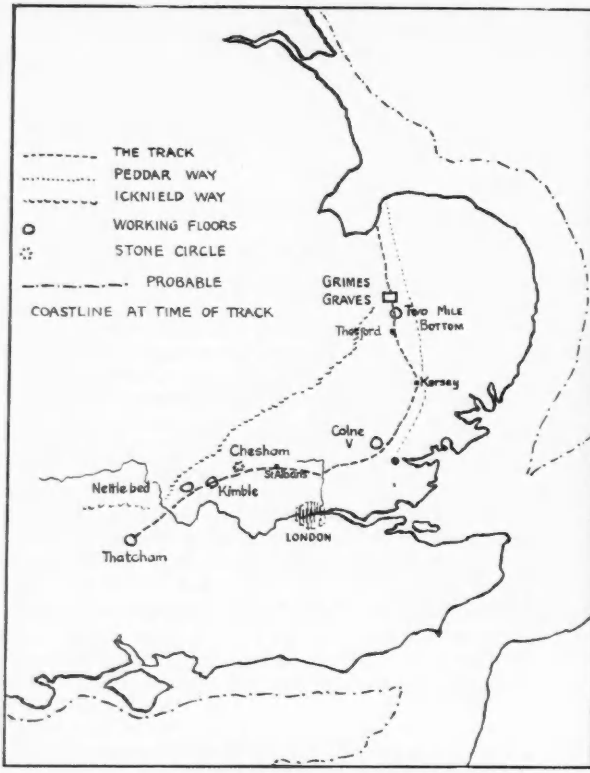

FIG. 1.—Outline Map of the Track

FIG. 3.—The Mashbury Stone

FIG. 2.—The Holyfield Stone

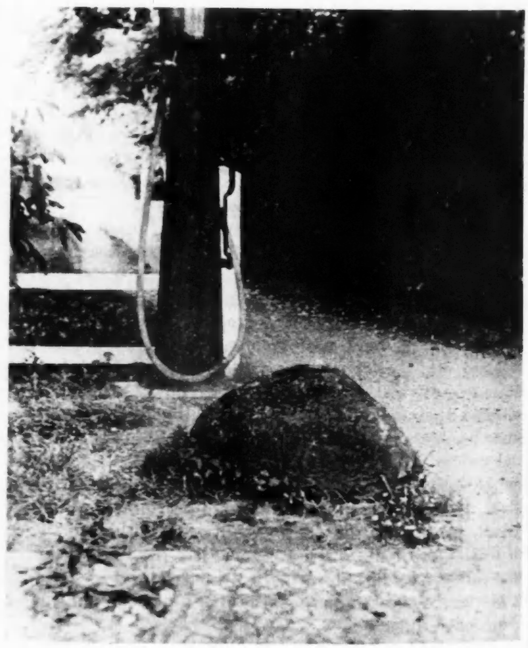

FIG. 4.—The Feeringbury Stone

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flowed shallow over a bed of gravel. Among the outstanding boulders of this Essex section we may mention the great stone lying in the churchyard at Beauchamp Roding; the handsome specimen at Mashbury Hall Farm, near Chelmsford (Fig. 3), dragged from Nightingale Wood a mile to the south; the famous White Notley Stone, on the roadside towards Witham; and the fordstone at Feeringbury, near Coggeshall, incongruously resting beside a petrol pump (Fig. 4).

At Marks Tey Church, five miles short of Colchester, and where the stone lies in the foundations of the north wall of the church tower, the trail turned towards the north, avoiding the well-known prehistoric site of Camulodunum. The River Colne was forded at Fordstreet, and the track led a little east of north to the Suffolk border at Nayland, on the River Stour. Still guided by the puddingstone trackstones we were led to the picturesque village of Kersey, where two stones lie in the village street, one embedded on the stream-bank at the water-splash. This village street was aligned along the track direction which pointed now to the north-north-east, leading us to the fine stone in the orchard of Drakestone Green Farm, across Chelsworth Common, and to Chelsworth Church. The character of the stones altered at this point, for the true puddingstone does not occur north of Kersey. Hertfordshire conglomerate is a constituent rock of the Reading beds, found in many areas of the south-eastern counties, but absent in East Anglia. Nevertheless, the track-builder kept to his original plan, using without exception a local recognisable conglomerate in which the pebbles could be clearly seen. It was this that brought home to us the ingenuity of the primitive surveyor who thus sign-posted his remarkable track in a roadless, featureless country.

At Chelsworth, our track was pointing in the general direction of Thetford, on the Norfolk border, where indeed the trail of stones eventually led us. The ford over the Little Ouse river was marked on both banks by great boulders, now resting in Maltings Lane on the south bank, and in Minstergate Street on the north, respectively. The importance of this ford over the deep and wide river is emphasised even in the very name of the place, Thetford, derived from a Saxon root meaning 'the people's ford'.

A Prehistoric Flint Mine

Across the Little Ouse the track bears to the west along the sandy ridge of ground along which runs the Mundford road, and finally leads to the prehistoric flint-mining site known as Grimes Graves. Here the conglomerate trackstone lies in a fir-grown hollow on the southern verge of the area, and we learned from an old inhabitant that before the trees were planted it stood clearly visible on the edge of the highest slope.

This then was the objective of the unique track which we had followed stone by stone for close on eighty miles from Holyfield, and in Grimes Graves lay its very purpose. It was here that the Stone Age miner dug down to the layer of tabular flint so highly prized for the fabrication of his tools and weapons, and along this track he carried the precious load to the centres of culture of his race.

It still remained for us to discover the western objective of the track which we began on the River Lea. As we had expected, the trail of stones reappeared on the western bank at Cheshunt, leading us in a similar way to St. Albans. This modern city has produced some of the most remarkable evidence of the extraordinary persistence of the trackstones, nearly all of which are still in position. The most remarkable one lies in a tiny front garden at New Kent Road (Fig. 5), where we found it had rested unnoticed and undisturbed for more than fifty years. The fordstone at the famous ford of St. Michael's on the River Ver still stands in the nearby Jones' Yard (Fig. 6), and on the western hill the stone had been incorporated by the Romans in the Triumphal Arch of their theatre. It may still be seen among the ruins—the only puddingstone found there.

From St. Albans the track may be followed to the west, but here we are in the native country of puddingstone, and greater skill and experience are required to differentiate between the true trackstone of antiquity and the recently quarried material. Great quantities of the rock underlie the countryside of Hertfordshire, and outcrops are frequently seen in cuttings and valleys. Yet we were able to follow the trail with confidence to the borders of Buckinghamshire at Leyhill, and along the gravel ridge which leads to Chesham.

It was at Chesham we made our most impressive discovery, that the ancient church is built upon the site of a puddingstone circle nearly 100 feet in diameter. The church is cruciform, and under the southern buttresses lie prostrate great blocks of the rock, some of which are up to eight feet long. We were puzzled at first to find no boulders under the northern wall of the nave, until we discovered that this wall was twice rebuilt in medieval times. The disturbed blocks were then heaped together and built into one buttress on the north-east.

Although we have traced the line of trackstones along the entire ridge of the Chiltern Hills, and across the Thames at Pangbourne, we still hold the opinion that this great prehistoric work on the site of Chesham Church indicates the supreme importance of this area as the cultural centre of the primitive track people. Up to the present we have surveyed the track for over 120 miles, in a great arc from the Chilterns through East Anglia to Grimes Graves, yet nowhere have we found an indication of cultural significance so pronounced as that at Chesham.

At the moment our researches end at Thatcham, near Newbury in Berkshire, but there is nothing to show that this will necessarily be the end of the trail. On the other hand, we have traced a very complete line of trackstones north of Grimes Graves through Cranwich, Gayton, Grimstone, Snettisham and Heacham, and it is probable that it will reappear in Lincolnshire. Enough has been accomplished, however, for us to draw certain conclusions concerning the age and purpose of the track.

How Old is the Track?

Almost certainly it was laid out by a primitive and pedestrian people of the Stone Age. The trackstones, of which we have hitherto found upwards of 130, show no evidence of movement over long distances, and this suggests that means of transport were limited. Most of the stones are quite small—up to three feet in length—and a few can be lifted in the arms of a strong man. Herein lies one of the

FIG. 5.—The Stone in New Kent Road, St. Albans

FIG. 6.—St. Michael's Fordstone, St. Albans

most extraordinary features of the track, for it is nothing short of a miracle that so many have survived the intensive population of this area for so many centuries.

Of the track itself nothing survives, for it was merely a footpath, yet again there are curious survivals in rights-of-way. In St. Albans the path of the track is preserved as an ancient passage known as Sovereign Way, leading east to west between rows of modern shops. At Great Missenden the trackstone lies beneath a fifteenth-century timber in the coaching yard entrance, and from here there is a continuous right-of-way including even a small foot-tunnel under the railway line. Here and there the track corresponds with footpaths, particularly in the Chiltern country, and occasionally with short stretches of modern roads. In Norfolk much of it lies along 'green roads', e.g. between Cockley Cley and Narford, yet for most of its distance the evidence for the track lies in little more than the connected sequence of its sighting-stones.

We cannot do more than hazard a guess at the authorship of the track, yet one thing is clear—it was made when the landscape was more open than at present. A great number of the stones lie in woods and thickets where in the heyday of the track the country must have been open. Again, the track swings in a great arc through the eastern counties for the sole purpose of keeping throughout its length to the gravel ridges and sandy plateaux. It avoids alike the chalk hills to the west and the clay-lands to the east. Finally, on or very near its course lie no fewer than six of the known Mesolithic flint 'workshop floors' found in eastern England, viz. Two-mile Bottom (Thetford), Colne Valley, Epping Forest, Nettlebed Common, Kimble Farm (Oxford) and Thatcham (Berks.).

All these circumstances considered together point only in one direction, that the track was constructed by people of a gravel-dwelling culture during one of the drier cycles of climate such as the Boreal. If this be so, it suggests the authorship of the Tardenoisian culture of Mesolithic Age, and the stones we have found must have survived the changes over the incredible period of at least six millennia.

As such, the conglomerate track takes its place as one of the most ancient surviving works of primitive man in Britain.

REFERENCES

Essex Naturalist, vol. 28, part 4, 1950.
Essex Naturalist, vol. 28, part 6, 1952.

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Plants of the Sea Coast

THE summer holidays bring out the naturalist in everybody, and for the holiday naturalist we have in previous summers provided photo-guides to help readers identify the kinds of animals and plants they may meet on their holidays. In August 1949, for instance, we published a set of photographs by Dr. Douglas P. Wilson showing a large number of common species of seashore animals, and in July 1950 we published photographs of a representative collection of seaweed species. This year we devote four pages to pictures of plants which are associated with the sea coast. These photographs were taken by Dr. Wilson and his wife, Dr. M. A. Wilson.

Coastal plants have been intensively studied by British plant ecologists, and there is a large specialist literature about them. A good ecological survey of dunes and salt marshes is to be found in Tansley's monumental *The British Islands and their Vegetation* (C.U.P., 1939). Most of this literature is, however, beyond the reach of the uninitiated, for whom the following notes about the ecology of coastal plants are intended.

Sand-dune plants. A ridge of fine and mobile sand does not constitute a habitat favourable to plant growth, and it is no surprise to find that dune plants exhibit certain special features which make for survival under environmental conditions so severe as to exclude the common flowering plants that flourish in nearby fields inland. The community of plants which colonise the coastal dunes is as exclusive as a West End club, and it is the environmental factors which so rigidly keep the outsiders out. Dune plants must meet certain qualifications. For example, they must be able to tolerate being buried by a substantial layer of sand. The Sea Holly (*Eryngium maritimum*) can do this to a striking degree. Winter winds shift a great deal of sand, and when the growing season starts in the spring the crown of the Sea Holly may be a good foot below the surface of the sand. Yet it has no difficulty in throwing up a strong shoot which grows swiftly upwards to meet the sun and produce a normal show of flowers in July.

Certain of the plants associated with dunes do not merely colonise dunes; they actually help in dune-building and in stabilising the dunes, holding the sand together and preventing its dispersal by wind and rain.

The first plants to colonise brand-new dunes brought into being by wind action must be able to tolerate salt. The most important of these plant pioneers is Sand Couch Grass (*Agropyron junceiforme*) which spreads by means of fast-growing rhizomes. This habit, the same habit which makes its near relative, the ordinary inland 'couch' or twitch, such a bane to gardeners and farmers, renders this grass a supreme dune-builder. Most people will be more familiar with another dune grass of similar habit, known as Marram Grass (*Ammophila arenaria*). This grows even more rapidly than *Agropyron*, but as it is far less tolerant of salt—it is even sensitive to salt in sea spray, which *Agropyron* can take without turning a rhizome—it normally only begins to colonise a dune behind the shelter of *Agropyron*.

Wherever plants can get a foothold a soil starts to be created. On a dune, once the pioneer plants like *Agropyron* and *Ammophila* have established themselves, humus starts to develop as dead plant fragments accumulate and decay. The soil of a dune is initially markedly alkaline, plenty of calcium carbonate being present. The calcium carbonate derives from the shells of molluscs and calcareous seaweeds. Then, as the dune gets older, the soil grows progressively more and more acid; partly because more and more plant remains accumulate in the sand, and partly because the calcium carbonate is constantly being leached out. A century-old dune usually shows a distinctly acid reaction, and in this condition can, and may, support acid-loving plants like heather.

Plants of Shingle Beaches. An eighth of the 2,500-mile coastline of Britain is occupied by stretches of shingle. Generally it carries few plants; indeed a shingle beach which contains no sand offers no roothold for plants and will develop no vegetation. Only one plant seems to have any power to bind together the pebbles of a shingle beach; this is *Suaeda fruticosa* (Sea Heath), a member of the Beet family (Chenopodiaceae). A few deep-rooted perennials can establish themselves on the protected side of shingle banks, such as the Sea Pink (*Silene maritima*) and certain species of Spurge.

Salt-marsh plants. The mineral base of a salt marsh is mud, composed of small clay particles deposited on quiet stretches of coast and up estuaries and creeks where wave action is small. These deposits tend to be swept away again when strong wave action or strong currents arise, and then it seems to make little or no difference whether the mud has been colonised by plants or not. For the plants distinctive of salt marshes are unable to hold the very fine mud particles together against wave or current action.

Unlike sand, clay particles do not tend to heap into piles; the liquid mud finds its own level, hence the flat unbroken vista presented by the average salt marsh. Moreover, most plants do not encourage any local accumulation of mud around their stems, and its subsequent stabilisation; a notable exception here is the grass known as *Spartina townsendii*, which has colonised mud flats all around Britain.

The pioneer plants of the salt-marsh community are algae—*Rhizoclonium* and *Vaucheria*, for example. Among the first flowering plants to follow them is Marsh Samphire (*Salicornia*). In structure this plant shows some resemblance to a cactus; in particular it lacks leaves, and one finds that what appears to be a succulent stem is not a true stem at all—cut a section and you find that the true stem is reduced to a thin strand in the middle, around which is a thick ring of tissue representing the bases of leaves. *Salicornia* seems to be more than tolerant of salt; it does not seem to be able to grow without it. (Most plants from salt marshes grow more luxuriously if they are cultivated on ordinary soil; if one plants *Salicornia* in the garden one finds that it languishes unless some salt is worked into the soil around it.)

The early community of salt-marsh plants is a very open community, the plants being few and far between. But as plant debris begins to accumulate and more silt is added, a soil favourable to a wider range of plant species comes into being and the gaps get filled up. It is at this stage that Sea Manna Grass (*Glyceria maritima*), salt-marsh counterpart of Marram and Sand Couch, usually makes its appearance. This grass, which tolerates salt and burial by silt, grows rapidly in the warm part of the year and is a very efficient mud-builder. With the establishment of this and other plants the level of the salt marsh is built up steadily. When it approaches high-tide level, plants less tolerant of submersion can come in, plants such as Thrift and Sea Lavender, as well as several species of grasses, chenopods and composites. Once the level of the salt marsh reaches the high-tide mark additional build-up becomes impossible.

It will come as a surprise to most people to find that the sticky mud of a salt marsh is actually well aerated; moreover, it usually shows a markedly alkaline reaction and it favours strong root action, contrary to what might at first sight be expected. The alkalinity is attributed to the large quantities of droppings from the many birds which thrive on salt marshes, while the flotsam brought in by the tides is relatively rich in calcium carbonate, containing as it does such items as crab shells. The good aeration of the soil is immediately apparent when the sea sweeps across a salt marsh: myriads of bubbles are to be seen streaming up from tunnels made in the mud by lugworms and holes left behind when plant roots rotted and disintegrated.

Most salt-marsh plants grow more vigorously inland on ordinary soil than they do in their natural habitat. (The difference between Thrift growing in a garden and Thrift in a salt marsh, for example, is very great indeed.) Yet these plants are ill adapted to meet the competition which is typical of a close inland community of plants, and they are swiftly overgrown and swamped by meadow plants such as grasses. This can be seen in an old salt marsh, where meadow plants become established on the inland side of the marsh and wipe out the original occupiers.

Readers wishing to identify individual plants should acquire one of the following floras: *A Flower Book for the Pocket*, by Macgregor Skene (O.U.P.); *British Flora*, by Gaston Bonnier (Dent); *Handbook of the British Flora*, by Bentham and Hooker (Reeve); *Flora of the British Isles*, by Clapham, Tutin and Warburg (C.U.P., 1952). The first two are the easiest to use. A very full account of the dune flora is provided in Sir Edward Salisbury's book, *Downs and Dunes*, to be published next month.

FIG. 1.—SEA HOLLY, *Eryngium maritimum*. A handsome plant of fixed sand dunes, with stiff, spiny leaves. The plant belongs to the Parsley family (Umbelliferae), but since the florets lack flower stalks the pale-blue flower-heads are globose and look rather thistle-like. In flower in July and August. The plant, which also grows on shingle, has a very long tap root, for which stimulating properties used to be claimed and which was the basis of the old sweetmeats 'candied eryngo' and 'kissing comfits'.

FIG. 2.—JERSEY CROCUS, *Romulea columnae*. A member of the Iris family, it is rare in Britain, being known on the mainland only from Dawlish Warren in Devon. It used to grow in Cornwall but is probably extinct there now. Its English name comes from its occurrence in the Channel Islands, and it is also found in western France. Its habitat is short turf on sandy soil. The milky blue flowers last only for a few days in the spring.

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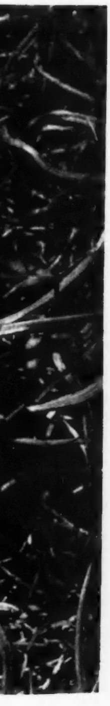


FIG. 3.—ROCK SAMPHIRE, *Crithmum maritimum*. Not to be confused with Marsh Samphire (*Salicornia*). *Crithmum* belongs to the Umbelliferae, whereas *Salicornia* is related to spinach and beet. The yellowish-green flowers are arranged in umbels like those of Parsley. It is most commonly encountered on cliffs or growing on rocks; sometimes it grows on shingle or sand by the sea.

FIG. 4.—SEA CONVOLVULUS, *Calystegia soldanella*. This plant, which is one of Britain's four bindweeds, is found on sandy or shingly seashores. In some localities it can be quite common. It blooms from June to August. The trumpet-shaped flowers are somewhat variable in colour; typically they are pink with white or yellowish stripes.

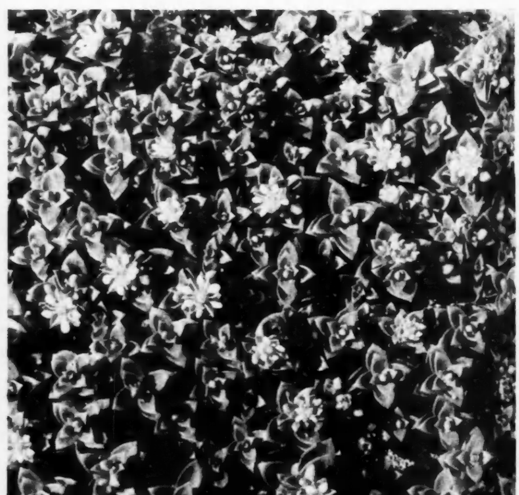
FIG. 5.—SLENDER THISTLE, *Carduus tenuiflorus*. This is one of the thistles that are late invaders of well-established sand-dune communities.

FIG. 6.—BUCK'S HORN PLANTAIN, *Plantago coronopus*. This plant is most common near the sea in sandy and gravelly places, as well as in cracks in rocks, but it also occurs inland on sandy and gravel soils. The leaves are deeply lobed, reminiscent of a stag's antlers, hence the English name.

FIG. 7.—SEA ROCKET, *Cakile maritima*. The fruit of the plant, which belongs to the Wallflower family, breaks into two-seed units which float; as the seeds survive being soaked in sea water, this plant has become widely distributed all around our coasts. It is a common drift-line plant on sandy and shingly seashores in many parts of the world. The leaves are succulent, the tap root long—two common adaptations for life in such a habitat.

FIG. 8.—MARRAM GRASS, *Ammophila* (= *Psamma arenaria*). A most important consolidator of sand dunes. It cannot tolerate much salt, with the result that quite often the Marram Grass growing at the base of a dune gets killed off by exceptionally high tides.

FIG. 9.—THRIFT (SEA PINK), *Armeria maritima*. Common on salt marshes, coastal pastures, rocks and cliffs. It also grows



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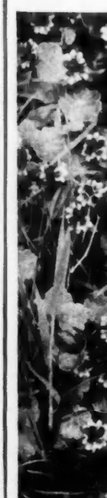
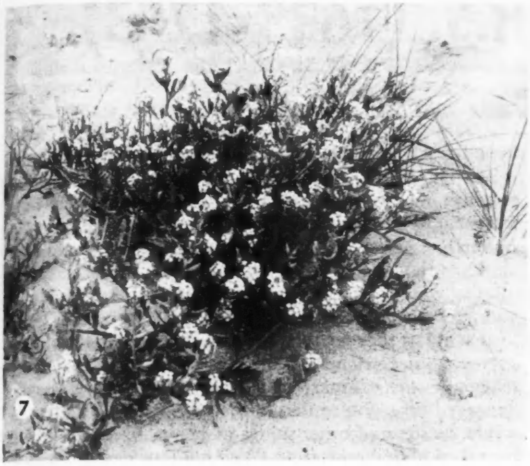




wild inland, usually favouring sandy heaths or high sandy ground—it is recorded from altitudes up to 4000 feet. A more robust species, *A. plantaginea*, occurs on stable sand dunes in Jersey.

FIG. 10.—SEA PURSLANE, *Honckenya peploides*. A succulent creeping herb which is common on sandy or shingle beeches. Associated with *Agropyron junceiforme* in early dune formation. Tolerant of short periods of immersion. A carpet of it covered with the greenish-white flowers gives off a heavy perfume on warm days.

FIG. 11.—SEA MILKWORT, *Glaux maritima*. A small creeping perennial, found on grassy salt marshes, and also growing in crevices of rocks or at the foot of cliffs by the sea or estuaries; also in saline districts inland. The flowers lack petals, but the sepals are coloured pink. (The flowers in this picture are those of Sea Milkwort; the umbrella-shaped leaves belong to plants of *Hydrocotyle vulgaris*.)

FIG. 12.—SEA SPLEENWORT, *Asplenium marinum*. Ferns are sensitive to salt, but this species occurs near the sea, usually in shady clefts and caverns. The fronds are bright green, the stem glossy at its base. Commonest on the west coasts of Britain and Eire.

8

Continued from p. 189 of the last issue

Samuel Pepys, F.R.S. (1633-1703)

DOUGLAS McKIE, D.Sc., Ph.D.

In the previous parts of this article some account has been given of the references to the Royal Society in Pepys's *Diary*, together with other references from Hooke's *Diary* and Birch's *History of the Royal Society* relating to Pepys's interest and activities in the work of the Society, of which he had been elected a Fellow on February 15, 1665. In this third part, we shall deal with other scientific matters of interest in Pepys's *Diary*, some connected with the Royal Society and others not.

Arithmetic and Mathematics

Pepys's interest in matters affecting his work and the efficient discharge of his duties in the Admiralty is very well instanced in his study of mathematics, for which purpose he sought instruction from Cooper, formerly of the *Charles* and in 1662 mate in the *Royal James*, to whom, on July 1, 1662, Pepys spoke "about teaching the mathematiques, and do please myself in my thoughts of learning of him, and bade him come to me in a day or two". They began, some days later, with the multiplication table, as Pepys recorded on July 4: "By and by comes Mr. Cooper, mate of the Royall Charles, of whom I intend to learn mathematiques, and do begin with him to-day, he being a very able man, and no great matter, I suppose, will content him. After an hour's being with him at arithmetique (my first attempt being to learn the multiplication-table); then we parted until to-morrow." They continued next evening after Pepys's work in the navy office was done. Next day, July 6, was "Lord's day", but the work went on on Monday: "and by and by comes Mr. Cooper, so he and I to our mathematiques, and so supper and to bed." On the evening of July 8 the lessons went on till late: "So he [Cooper] and I to work till it was dark, and then eat a bit and by daylight to bed." Next morning Pepys rose early: "Up by four o'clock, and at my multiplicacion-table hard, which is all the trouble I meet withal in my arithmetique." That evening Pepys recorded once more: "Mr. Cooper and I to our business." Next morning Pepys again rose early and "practised my arithmetique"; and on July 11, he was "up at four o'clock, and hard at my multiplicacion-table, which I am now almost master of". And so it went on: "with Cooper at arithmetique" on the 12th; after "Lord's day" on the 13th, Pepys was "up by 4 o'clock" on the 14th "and to my arithmetique"; and on the 15th he took Cooper on the river "on purpose to tell me things belonging to ships".

Official duties were, however, heavy; and on July 18 Pepys was fully occupied until late, "till night, and then comes Cooper for my mathematiques, but, in good earnest, my head is so full of business that I cannot understand it as otherwise I should do". Again on July 19 and 28 Cooper went on with his pupil, whom he accompanied on July 29 walking to Deptford, "talking of mathematiques". On July 30, the subject changed: "Up early, and to my office, where Cooper came to me and begun his lecture upon the body of a ship, which my having of a model in the office is of great use to me, and very pleasant and useful it is." The day ended on a different note: Pepys went down the river to Woolwich with Captain Fletcher of the *Gage* to see Sir William Batten, then at work on the survey; but Batten had not come, so Pepys and Fletcher "got a dish of steaks at the White Hart", while Batten's clerks and some others "were feasting of it in the best room of the house, and after dinner playing at shuffleboard", but, adds Pepys, "when at last they heard I was there, they went about their survey. But God help the King! what surveys shall be taken after this manner!" As for Pepys, dinner being over, he stayed till night, testing in the rope-yard "the strength, wayte, waste, and other things of hemp, by which I have furnished myself enough to finish my intended business of stating the goodness of all sorts of hemp".

A year later, Pepys was told about "duodecimal arithmetique" when he was discussing "mathematiques" with Creed on June 9, 1663; Creed told him "of a way found out by Mr. Jonas Moore, which he calls duodecimal arithmetique, which is properly applied to measuring, where all is ordered by inches, which are 12 in a foot, which I have a mind to learn". Jonas Moore (1617–79), tutor to the Duke of York and foundation Fellow of the Royal Society, was a well-known mathematician and author of *Arithmetick* (1650) and other mathematical works.

Mrs. Pepys, too, was taught arithmetic; on October 21, 1663, Pepys recorded in his diary: "This evening after I came home I begun to enter my wife in arithmetique, in order to her studying of the globes, and she takes it very well, and, I hope, with great pleasure, I shall bring her to understand many fine things." After dinner next day Mrs. Pepys continued: "and after dinner with my wife to her study and there read some more arithmetique, which she takes with great ease and pleasure." On October 30, Pepys went on "to a new lesson in arithmatique with her"; and on the evening of November 1, "Lord's day", he recorded that he taught her "some part of subtraction", while on November 5 he wrote that "my wife and I to her arithmetique, in which she pleases me well", and on November 11 in his office "and there taught my wife a new lesson in arithmetique and so sent her home". He continued to help his wife with her studies in the afternoons and evenings of December 2 and 5, while on December 6, "Lord's day", he recorded that, after spending some time at arithmetic on his own in the morning, Mrs. Pepys joined him in the afternoon: "So my wife rose anon, and she and I all the afternoon at arithmetique, and she is come to do Addition, Subtraction, and Multiplicacion very well, and so I purpose not to trouble her yet with Division, but to begin with the Globes to her now."

Slide Rules

Pepys, always concerned in proving himself an efficient Admiralty official, seems to have taken much interest in the slide rules used for measuring timber, an important naval supply in the days of England's 'wooden walls'. On March

24, 1663, he could not agree about the price for "White's ruler to measure timber with", when he proposed to buy one from Browne, instrument maker in the Minories; but he seems to have bought one, entering in his diary on April 14 that he "walked to Greenwich, studying the slide rule for measuring of timber, which is very fine", while on the next day, April 15, he records that he walked back from Deptford, "all the way reading of my book of Timber measure, comparing it with my new Sliding Rule brought home this morning with great pleasure". On May 5, Deane of Woolwich showed him another slide rule, "less than that I bought the other day, which is the same with that, but more portable; however I did not seem to understand or even to have seen anything of it before, but I find him an ingenious fellow, and a good servant in his place to the King"; and on May 11, going to and returning from Woolwich by water, Pepys says that he "did con my lesson on my Ruler to measure timber, which I think I can well undertake now to do". On June 9 in his office he "spent the morning upon my measuring rules very pleasantly till noon"; and on June 11, he recorded: "Up and spent most of the morning upon my measuring Ruler and with great pleasure I have found out some things myself of great despatch, more than my book teaches me, which pleases me mightily."

Shortly afterwards, on July 18, Pepys called on Thomson, an instrument maker, "to bespeak a ruler for my pocket for timber, &c., which I believe he will do to my mind". It would seem, however, that this instrument was eventually made by Browne, the instrument maker in the Minories, whom we have already mentioned: for, on August 8, Pepys recorded that Browne brought "a ruler for measuring timber and other things so well done and in all things to my mind that I do set up my trust upon it that I cannot have a better, nor any man else have so good for this purpose, this being of my own ordering". Indeed, Pepys had called on Browne on the previous day, August 7, "for my measuring rule, which is made, and is certainly the best and the most commodious for carrying in one's pocket, and most useful that ever was made, and myself have the honour of being as it were the inventor of this form of it". Despite the dates of these entries, Pepys seems to have had the ruler in his possession on August 7 in Deptford, where, in Sir William Penn's presence, he began to measure timber much more quickly than the measurer, and noted that he believed "Sir W. Pen would be glad I could have done less and he more", and he had studied it before going to Deptford, "till my head aked cruelly".

Pepys took great pride in this instrument. Three days later, on August 10, he went to see Greatorex, another instrument maker, with whom he was friendly, "and set him to work upon my ruler, to engrave an almanac and other things upon the brasses of it, which a little before night he did, but the latter part he slubbered over, that I must get him to do it over better, or else I shall not fancy my rule". On the 15th, he wrote: "After dinner walked forth to my instrument maker, and there had my rule he made me lay now so perfected, that I think in all points I have never need or desire a better, or think that any man yet had one so good in all the several points of it for my use." And a year later, on August 10, 1664, he wanted "to find out one to engrave my tables upon my new sliding rule with silver plates, it being so small that Browne that made it cannot get one to do it". The work was undertaken and completed next day by Cocker "to admiration, for goodness and smallness of work", recorded Pepys: "it cost me 14*s*. the doing, and mightily pleased I am with it". Indeed, that same evening, he could not "forbear admiring and consulting my new rule".

Instruments and Instrument Makers

Besides Browne and the Thomson, incidentally mentioned by Pepys on July 18, 1663, Pepys was also well acquainted with the famous instrument maker, Ralph Greatorex (*ob.* 1712 ?); and both Pepys and Greatorex were friends of "Mr. Spong", who is frequently mentioned in Pepys's *Diary*.

On October 23, 1660, Pepys went "to White Hall, where I met Mr. Spong, and went home with him and played, and sang, and eat with him and his mother". He went on to record: "After supper we looked over many books, and instruments of his, especially his wooden jack in his chimney, which goes with the smoke, which indeed is very pretty. I found him to be as ingenious and good-natured a man as ever I met with in my life, and cannot admire him enough, he being so plain and illiterate a man as he is." Next day, Pepys called at the house of William Lilly (1602–81), astrologer, compiler of the almanac, *Merlinus Anglicus Junior, the English Merlin revived*, which first appeared in 1644, and author of works on astrology; he had hoped to meet Spong there, but found him at the house of Greatorex; all three went to an ale-house, where Pepys bought a drawing-pen from Greatorex, who "did show me the manner of the lamp-glasses, which carry the light a great way, good to read in bed by, and I intend to have one of them". Then, accompanied by Spong, Pepys returned to Lilly's, where he was "well received, there being a club to-night among his friends", and where he met Elias Ashmole (1617–92), Windsor Herald, antiquary and astrologer, editor of the well-known collection of alchemical works by English writers, *Theatrum Chemicum Britannicum* (1652) and founder of the Ashmolean Museum. "With him," wrote Pepys, "we two sang afterward in Mr. Lilly's study. That done, we all parted." A pleasant scene—Pepys, Ashmole and Spong singing in Lilly's study in the autumn of the Restoration year. Going home by coach, Pepys took with him John Booker (1603–67), astrologer, "who", wrote Pepys, "did tell me a great many fooleries, which may be done by nativities, and blaming Mr. Lilly for writing to please his friends and to keep in with the times (as he did formerly to his own dishonour), and not according to the rules of art, by which he could not well err, as he had done". There was still much that was not science in seventeenth-century thought, although this was strange company for a future Fellow and President of the Royal Society of London. Pepys met Ashmole again on May 23, 1661, at the Lord Mayor's: "At table I had very good discourse with Mr. Ashmole, wherein he did assure me that frogs and many insects do often fall from the sky, ready formed."

On October 2, 1663, Pepys received "a letter from Mr. Barlow, with a Terella, which I had hoped he had sent me, but to my trouble I find it is to present from him to my

Lord Sandwich, but I will make a little use of it first, and then give it to him". Pepys would be much interested in this: the terrella, or 'little Earth', had been invented by William Gilbert of Colchester (1540–1603), physician to Queen Elizabeth, founder of the science of magnetism and author of the classic *De Magnete* (1600), and was a spherical loadstone, which in its shape resembled the earth and by its magnetic properties could be used to illustrate the magnetic properties of the earth, compass-needles pointing to its poles as they likewise did to the poles of the earth. Barlow, Pepys's correspondent, was the author of *Magneticall Aduertisements* (1616). Pepys appears to have retained the terrella that Barlow had sent for Lord Sandwich until November 25, since he records on that date: "to my Lord Sandwich's, and there I did present him Mr. Barlow's 'Terella', with which he was very much pleased."

Of Ralph Greatorex, the instrument maker, there is frequent reference in the diary. On January 10, 1660, he showed Pepys in an ale-house "the first sphere of wire that ever he made, and indeed it was very pleasant". On October 11 of that year, Pepys went to see the engines for raising water, recording: ". . . in St. James's Park, where we observed the several engines at work to draw up water, with which sight I was very much pleased. Above all the rest, I liked best that which Mr. Greatorex brought, which is one round thing going within all with a pair of stairs round; round which being laid at an angle of 45°, do carry up the water with a great deal of ease." From Pepys's description, the apparatus may be recognised as an Archimedes screw. On September 22, 1662, Pepys "walked to Greatorex's, and there with him did overlook many pretty things, new inventions, and have bespoke a weather glass of him", which was brought on March 23, 1663: "This day", wrote Pepys, under that date, "Greatorex brought me a very pretty weather-glass for heat and cold." A week later, on March 30, he entered in his diary: "Up betimes and found my weather-glass sunk again just to the same position which it was last night before I had any fire made in my chamber, which had made it rise in two hours time above half a degree." This "weather-glass for heat and cold" was probably not one of the so-called Galilean thermoscopes, but the more recently invented spirit-thermometer.

Later, on October 29 of that year, Pepys discussed with Greatorex the latter's plan for draining the Fens, of which, however, nothing seems to be now known; Pepys's opinion was: "but it did not appear very satisfactory to me, as he discoursed it, and I doubt he will faile in it".

Earlier, on the wet Whit-Sunday of 1661, June 2, Pepys had, on returning home from his second attendance at church that day, "found Greatorex (whom I expected to-day at dinner) come to see me, and so he and I in my chamber drinking of wine and eating of anchovies an hour or two, discoursing of many things in mathematics, and among others he showed me how it comes to pass the strength that levers have, and he showed me that what is got as to matter of strength is lost by them as to matter of time. It rained very hard, as it hath done of late so much that we begin to doubt a famine, and so he was forced to stay longer than I desired."

Of Browne, the instrument maker, there are other references than those relating to the slide rule. On January 16, 1664, Pepys wrote that "Browne of the Minerys brought me an Instrument made of a Spyral line very pretty for all questions in Arithmetique almost, but it must be some use that must make me perfect in it". This may have been ordered by Pepys on December 26, 1663, when he went to Browne's "and there with great pleasure saw and bespoke several instruments".

Some years later, in 1669, on April 30, Pepys called on Oldenburg and saw "the instrument for perspective made by Dr. Wren, of which I have one making by Browne: and the sight of this do please me mightily". Christopher Wren's instrument is described in the *Philosophical Transactions* (1669, *4*, 898): its use was "for drawing the Out-lines of any Object in Perspective". On May 8, Pepys wrote: "By and by also comes Browne, the mathematical instrument maker, and brings me home my instrument for perspective, made according to the description of Dr. Wren's, in the late Transactions; and he hath made it, I think, very well, and that, that I believe will do the thing, and therein gives me great content."

On September 26, 1667, Jonas Moore, as Pepys records, told him of the calculating machine known as "Napier's Bones", the device made by John Napier of Merchiston (1550–1617), the inventor of logarithms: "Jonas Moore comes . . . and tells me of the mighty use of Napier's bones; so that I will have a pair presently." Some months later, on March 14, 1668, Pepys saw Morland's calculating machine, but thought little of it: "Sir Samuel Morland's late invention for casting up of sums of *£. s. d.*; which is very pretty, but not very useful."

At Spong's house, on December 9, 1668, accompanied by Mrs. Pepys, Pepys "had most infinite pleasure, not only with his ingenuity in general, but in particular with his shewing me the use of the Parallelogram, by which he drew in a quarter of an hour before me, in little, from a great, a most neat map of England—that is, all the outlines, which gives me infinite pleasure, and foresight of pleasure, I shall have with it; and therefore desire to have that which I have bespoke, made. Many pretty things he showed us, and did give me a glass bubble, to try the strength of liquors with." The first instrument mentioned here, "the Parallelogram", is better known as the pantograph; the second is a

BOYLE'S HYDROMETER

Boyle's description in the *Philosophical Transactions* reads as follows, "A Glass-Tube . . . blown at a Lamp, and poised in good common water by putting *Quick-silver* into it, until it sink so low, that nothing appear above the Superficies of the Water, but the Top; which done it is to be sealed up, and to be graduated on its side, into what parts you please; which may be done with a Diamond. And then, being put into any Water to be weighed, it will, by its more or less sinking into it, shew the differences of the Waters gravity."

hydrometer, possibly in the form devised by Boyle and illustrated in the *Philosophical Transactions* (1667, 2, 447).

Pepys had already been much interested in the pantograph. On October 27, 1668, he wrote: "This evening Mr. Spong come, and sat late with me, and first told me of the instrument called parallelogram, which I must have one of, shewing me his practice thereon, by a map of England." Again, as we have mentioned, he saw this with Mrs. Pepys on December 9; and on January 13, 1669, he recorded: "This day come home the instrument I have so longed for, the Parallelogram." On January 17, "Lord's day", he wrote: "After dinner, Mr. Spong and I to my closet, there to try my instrument Parallelogram, which do mighty well, to my full content, but only a little stiff, as being new." But it needed further attention and on February 4, Pepys recorded: ". . . after dinner comes Mr. Spong to see me, and brings me my Parallelogram, in better order than before, and two or three draughts of the port of Brest, to my great content, and I did call Mr. Gibson to take notice of it, who is very much pleased therewith; and it seems that this Parallelogram is not, as Mr. Sheres would, the other day, have persuaded me, the same as a Protractor, which do so much the more make me value it, but of itself is a most usefull instrument." Indeed, Pepys liked it so well that he ordered another on the same day, leaving the demonstration in company with Mrs. Pepys and Gibson for that purpose: "Thence out with my wife and him, and carried him to an instrument-maker's shop in Chancery Lane, that was once a 'prentice of Greatorex's, but the master was not within, and there he [Gibson] shewed me a Parallelogram in brass, which I like so well that I will buy, and therefore Bid it be made clean and fit for me." The instrument was delivered on February 10: "This day, at dinner, I sent to Mr. Spong to come to me to Hercules Pillars, who come to us, and there did bring with him my new Parallelogram of brass, which I was mightily pleased with, and paid for it 25*s*., and am mightily pleased with his ingenious and modest company." On April 22, Pepys presented a "Parallelogram" to Captain Deane, "which he is mightily taken with".

Perspective Glasses

On February 11, 1661, Pepys bought a small "perspective" from "young Mr. Reeve", another instrument maker. The term 'perspective' was applied both to the telescope and the microscope, but here the former probably was meant. Pepys paid five shillings for the instrument.

Some years later, on August 7, 1666, he recorded: "In the evening comes Mr. Reeves, with a twelve-foote glasse . . . so Reeves and I . . . up to the top of the house, and there we endeavoured to see the moon, and Saturne and Jupiter; but the heavens proved cloudy, and so we lost our labour, having taken pains to get things together, in order to the managing of our long glasse." But the next night was "a mighty fine bright night", and Pepys with Reeves was "upon my leads, though very sleepy, till one in the morning, looking on the moon and Jupiter, with this twelve-foote glasse and another of six foote, that he hath brought with him to-night, and the sights mighty pleasant, and one of the glasses I will buy, it being very usefull. So to bed mighty sleepy, but with much pleasure."

On August 19, "Lord's day", he wrote: "But by and by comes by agreement Mr. Reeves, and after him Mr. Spong, and all day with them, both before and after dinner, till ten o'clock at night, upon opticke enquiries, he bringing me a frame he closes on, to see how the rays of light do cut one another, and in a darke room with smoake, which is very pretty. He did also bring a lanthorne with pictures in glasse, to make strange things appear on a wall, very pretty. We did also at night see Jupiter and his girdle and satellites, very fine, with my twelve-foote glasse, but could not Saturne, he being very dark. Spong and I had also several fine discourses upon the globes this afternoon, particularly why the fixed stars do not rise and set at the same houre all the yeare long, which he could not demonstrate, nor I neither, the reason of. So, it being late, after supper, they away home. But it vexed me to understand no more from Reeves and his glasses touching the nature and reason of the several refractions of the several figured glasses, he understanding the acting part, but not one bit the theory, nor can make any body understand it, which is a strange dullness, methinks."

Three days later, on August 22, Pepys wrote: ". . . and so home, and there find Reeves, and so up to look upon the stars, and do like my glasse very well, and did even with him for it and a little perspective and the Lanthorne that shows tricks, altogether costing me £9 5*s*. 0*d*." But the "little perspective" appears again in the diary in church on "Lord's day", May 26, 1667, when Pepys recorded: "but I did entertain myself with my perspective glass up and down the church, by which I had the great pleasure of seeing and gazing at a great many very fine women: and what with that, and sleeping, I passed away the time till sermon was done." And on July 13, 1668, Pepys ordered from Reeves another "little perspective" and at the same time records that he was "mightily pleased with seeing objects in a dark room".

Pepys had always shown an interest in optics and his sight had already become an anxiety to him. On July 28, 1666, accompanying Lord Brouncker in his coach to Highgate to Lauderdale House (in the present Waterlow Park), he talked on the subject of optics: "All the way going and coming I learning of him the principles of Optickes, and what it is that makes an object seem less or bigger and how much distance do lessen an object, and that it is not the eye at all, or any rule of optiques, that can tell distance, but it is only an act of reason comparing of one mark with another, which did both please and inform me mightily." On July 3, 1668, he went with Pierce, the surgeon, Dr. Clarke, Dr. Waldron, Dr. Turberville, who had attended him for the trouble in his eyes, and Dr. Richard Lower, "to dissect several eyes of sheep and oxen, with great pleasure, and to my great information. But strange that this Turberville should be so great a man, and yet, to this day, had seen no eyes dissected, or but once, but desired this Dr. Lowre to give him the opportunity to see him dissect some."

Minting and Assaying: Chemistry

On May 19, 1663, Pepys went to the Mint and afterwards entered in his diary an account of all that he had seen. While much of this deals with the actual process of

minting, all of which he recorded in detail, his account of assaying is of interest because of the clarity of its composition by one who had no technical knowledge of chemistry. He wrote: ". . . after dinner went to the Assay Office and there saw the manner of assaying of gold and silver, and how silver melted down with gold do part, just being put into aqua-fortis, the silver turning into water, and the gold lying whole in the very form it was put in, mixed of gold and silver, which is a miracle; and to see no silver at all but turned into water, which they can bring again into itself out of the water. And here I was made thoroughly to understand the business of the fineness and coarseness of metals, and have put down my lessons with my other observations therein." He went on to record the assaying of bullion, either of gold or of silver, and gave a clear account of cupellation, which is worth quoting: "Before they do anything they assay the bullion, which is done, if it be gold, by taking an equal weight of that and of silver, of each a small weight, which they reckon to be six ounces or half a pound troy; this they wrap up within lead. If it be silver, they put such a quantity of that alone and wrap it up in lead, and then putting them into little earthen cupps made of stuff like tobacco pipes, and put them into a burning hot furnace, where, after a while, the whole body is melted, and at last the lead in both is sunk into the body of the cupp, which carries away all the copper or dross with it, and left the pure gold and silver embodyed together, of that which hath both been put into the cupp together, and the silver alone in these where it was put alone in the leaden case. And to part the silver and the gold in the first experiment, they put the mixed body into a glass of aqua-fortis, which separates them by spitting out the silver into such small parts that you cannot tell what it becomes, but turns into the very water and leaves the gold at the bottom clear of itself, with the silver wholly spit out, and yet the gold in the form that it was doubled together in when it was a mixed body of gold and silver, which is a great mystery; and after all this is done to get the silver together out of the water is as strange."

On January 13, 1662, at dinner in his house, Pepys was shown the "experiment" of the "chymicall glasses", that is, of Prince Rupert's Drops, "which break all to dust by breaking off a little small end; which is a great mystery to me". The 'drops' were formed by dropping molten glass 'bubbles' into water; on the Continent, whence they had been introduced into England by Prince Rupert as a 'curiosity', they were known as 'Dutch Tears'; they were made with thin glass 'tails' and, when these latter were nipped off, the 'tears' or 'drops', really glass bubbles, burst into pieces.

Respiration was another problem that interested the virtuosi of Pepys's day and it was much studied by the Royal Society. After the first meeting that followed the interruption caused by the Great Plague, Pepys was at the Crown Tavern with a number of the Fellows and there was much talk, "but", he wrote, "what among other fine discourse pleased me most was, Sir G. Ent [Sir George Ent (1604–89), M.D., F.R.S., twice President of the College of Physicians] about Respiration; that it is not to this day known, or concluded on among physicians, nor to be done either, how the action is managed by nature, or for what use it is". (The researches of Boyle on this problem have recently been summarised in this journal: see DISCOVERY, 1951, XII, 125–7.)

But Pepys was no chemist, as may be seen from what he wrote under the date of January 15, 1669, when, after walking with the King and the Duke of York in the Park, he saw the King's laboratory: "Then down with Lord Brouncker to Sir R. Murray, into the King's little elaboratory, under his closet, a pretty place; and there saw a great many chymical glasses and things, but understood none of them." Earlier, Pepys had shown himself interested in chemistry on July 5, 1663, when he wrote: ". . . Sir J. Minnes and I in his coach together, talking all the way of chymistry, wherein he do know something, at least, seems so to me, that cannot correct him."

Ancient and Modern: Aristotle, Galen, Paracelsus, Bacon, Descartes

The diary tells us something of Pepys's knowledge of the natural philosophy of the ancients and the moderns.

Of Bacon, Pepys records that he bought his "Organon" on May 15, 1660, with two other books, all "for the love of the binding", at The Hague. He greatly admired Bacon's *Faber Fortunae*, though, whether he is referring to one of Bacon's *Essays* or to a chapter of the *Advancement of Learning*, is not clear; but he often returned to read this.

Pepys's main interest in the writings of Descartes lay in the latter's works on music. On April 3, 1668, he went "by coach to Duck Lane, to look out for Marsanne, in French, a man that has wrote well of musique, but it is not to be had, but I have given order for its being sent for over [Marin Mersenne (1588–1648), *L'Harmonie Universelle, contenant la théorie et la pratique de la Musique* (Paris, 1637, 2 vols., Latin (enlarged) edition, Paris, 1648], and I did here buy Des Cartes his little treatise of musique [*Musicæ Compendium*, Amsterdam, 1617], and so home, and there to read a little." However, some two or three weeks later, on April 18, he obtained a copy of the English translation, *Musicæ Compendium, translated by a Person of Honour* (London, 1653). The translator was Pepys's associate in the Admiralty and the Royal Society, Viscount Brouncker. Pepys made his boy read it to him on Christmas day, 1668, while Mrs. Pepys "sat undressed all day, till ten at night, altering and lacing of a noble petticoat: while I by her, making the boy read to me the life of Julius Cæsar, and Des Cartes' book of Musick—the latter of which I understand not, nor think he did well that writ it, though a most learned man."

And on May 28, he recorded: ". . . being pleased that this morning my bookseller brings me home Marcennus's [Mersenne's] book of musick, which cost me £3 2*s*.; but is a very fine book." This was Mersenne's *Harmonie Universelle*, Pepys's order for which we have already mentioned as given on April 3.

Possibly it was his interest in music that led him to Descartes; and there is an entry in the diary for August 8, 1666, where he says that, walking with Reeves to the Temple, he met Hooke in the street and discoursed with him a little "about the nature of sounds, and he did make me understand the nature of musicall sounds made by strings, mighty prettily; and told me that having come to a certain number of vibrations proper to make any tone, he

is able to tell how many strokes a fly makes with her wings (those flies that hum in their flying) by the note that it answers to in musique during their flying. That, I suppose, is a little too much refined; but his discourse in general of sound was mighty fine."

One entry in Pepys's diary shows that the struggle between the older medicine of Galen and the newer medicine or "chymistry" of Paracelsus was far from over: on November 3, 1663, in a coffee-house, Pepys met an old Cambridge friend, Dr. Thomas Allen, sometime physician to Bethlehem hospital, and he records: ". . . to the Coffee-house, and there heard a long and most passionate discourse between two doctors of physique, of which one was Dr. Allen, whom I knew at Cambridge, and a couple of apothecarys; these maintaining chymistry against their Galenicall physique; and the truth is, one of the apothecarys whom they charged most, did speak very prettily, that is, his language and sense good, though perhaps he might not be so knowing a physician as to offer to contest with them. At last they came to some cooler terms, and broke up."

Coaches and 'Chariots'

As an instance of the wide interest of the Royal Society of Pepys's day in all kinds of mechanical inventions, we may refer to the 'Chariot', on which they passed their opinion. On January 11, 1666, Pepys records that he went with Lord Brouncker "to Gresham College to have seen Mr. Hooke and a new invented chariott of Dr. Wilkins, but met with nobody at home". The Society had not yet resumed their meetings after the long interruption caused by the Great Plague; at their last meeting (June 28, 1665), Hooke had been instructed to continue with his work, including the 'chariot-wheels'; when they met again eight months later, on March 14, 1666, Wilkins and Hooke reported that, with regard to the work on the chariot, "after great variety of trials they conceived, that they had brought it to a good issue, the defects found, since the chariot came to London, being thought easy to remedy. It was one horse to draw two persons with great ease to the riders, both him who sits in the chariot, and him who sits over the horse upon a springy saddle; that in plain ground 50 pound weight, descending from a pully, would draw this chariot with two persons. Whence Mr. Hooke inferred, that it was more easy for a horse to travel with such a draught, than to carry a single person: That Dr. Wilkins had travelled in it, and believed, that it would make a very convenient post-chariot." Wren and Hooke were ordered to "join in mending what might be amiss in this chariot, and endeavour to bring it to perfection". Meanwhile, on January 22, 1666, a trial had been held, which was recorded by Pepys in his diary: ". . . my Lord Bruncker being going with Dr. Wilkins, Mr. Hooke, and others, to Colonell Blunt's, to consider again of the business of chariots, and to try their new invention. Which I saw here my Lord Bruncker ride in; where the coachman sits astride upon a pole over the horse, but do not touch the horse, which is a pretty odd thing; but it seems it is most easy for the horse, and, as they say, for the man also."

Colonel Blunt had already been engaged on the problem of the improvement of coaches. On May 1, 1665, Brouncker, Moray, Wilkins and Hooke, travelling by coach to dinner at Colonel Blunt's house at Wricklesmarsh (nowadays Blackheath Park), met Pepys who can now be quoted to relate what followed: "So they stopped and took me with them. Landed at the Tower-wharf, and thence by water to Greenwich; and there coaches met us; and to his house, a very stately sight for situation and brave plantations; and among others, a vineyard, the first that ever I did see. No extraordinary dinner, nor any other entertainment good; but only after dinner to the tryall of some experiments about making of coaches easy. And several we tried; but one did prove mighty easy (not here for me to describe, but the whole body of the coach lies upon one long spring), and we all, one after another, rid in it; and it is very fine and likely to take. These experiments were the intent of their coming, and pretty they are."

But the day was not done and Pepys continued: "Thence back by coach to Greenwich, and in his pleasure boat to Deptford, and there stopped and into Mr. Evelyn's [Sayes Court], which is a most beautiful place; but it being dark and late, I staid not; but Deane Wilkins and Mr. Hooke and I walked to Redriffe; and noble discourse all day long did please me, and it being late did take them to my house to drink, and did give them some sweetmeats, and thence sent them with a lanthorn home, two worthy persons as are in England, I think, or the world."

Later in the year, on September 5, Pepys was dining with Brouncker at Greenwich, when Colonel Blunt arrived "in his new chariot made with springs", records Pepys, who went on to say: "as that was of wicker, wherein a while since we rode at his house. And he hath rode, he says, now this journey, many miles in it with one horse, and out-drives any coach, and out-goes any horse, and so easy, he says." Pepys wished to see for himself: "So for curiosity I went into it to try it, and up the hill to the heath [from Greenwich to Blackheath], and over the cart-rutts and found it pretty well, but not so easy as he pretends, and so back again, and took leave of my Lord and drove myself in the chariot to the office."

The Transfusion of Blood

As we have seen in the earlier parts of this article, the transfusion of blood had been suggested and, in fact, performed on animals and once on a human subject in the years covered by Pepys's diary. It was a problem that aroused wide interest; and Pepys referred to it a number of times. We have already mentioned the experiment made before the Royal Society on November 14, 1666, in which the blood of a mastiff was transfused into a spaniel. Pepys was not present at that meeting, but in talk at the Pope's Head Tavern in the evening, he discussed the experiment with Croone (William Croone, 1633–84, M.D., F.R.S., distinguished physician and founder of the Royal Society's Croonian Lecture): "This did give occasion", wrote Pepys, "to many pretty wishes, as of the blood of a Quaker to be let into an Archbishop, and such like; but, as Dr. Croone says, may, if it takes, be of mighty use to man's health, for the amending of bad blood by borrowing from a better body." There was more talk on November 16, when Hooke told Pepys that "the dog which was filled with another dog's blood, at the College the other day, is very

well, and like to be so as ever, and doubts not its being found of great use to men; and so do Dr. Whistler, who dined with us at the taverne."

In 1667, on November 23, at Arundel House, the first experiment was performed on a human subject. Two days earlier, Pepys discussed the political news with Wilkins and Whistler at the tavern in St. Clement's Churchyard and added: "From this we fell to other discourse, and very good; among the rest they discourse of a man that is a little frantic, that hath been a kind of minister, Dr. Wilkins saying that he hath read for him in his church, that is poor and a debauched man, that the College [i.e. the Royal Society] have hired for 20*s*. to have some of the blood of a sheep let into his body; and it is to be done on Saturday next. They purpose to let in about twelve ounces; which, they compute, is what will be let in in a minute's time by a watch. They differ in the opinion they have of the effects of it; some think it may have a good effect upon him as a frantic man by cooling his blood, others that it will not have any effect at all. But the man is a healthy man, and by this means will be able to give an account what alteration, if any, he do find in himself, and so may be usefull. On this occasion, Dr. Whistler told a pretty story related by Muffett, a good author, of Dr. Caius, that built Keys College; that, being very old, and living only at that time upon woman's milk, he, while he fed upon the milk of an angry, fretful woman, was so himself; and then, being advised to take it of a good-natured, patient woman, he did become so, beyond the common temper of his age. Thus much nutriment, they observed, might do." Pepys found their discourse "very fine": and on this occasion, as we have noted earlier, he expressed the hope that, "if I should be put out of my office, I do take great content in the liberty I shall be at, of frequenting these gentlemen's company".

Preparations for the experiment were ordered by the Royal Society at the meeting of November 21: "Dr. Lower having acquainted the society, that one Arthur Coga was willing to suffer the experiment of transfusion to be tried upon himself for a guinea, it was resolved, that the offer should be accepted, and the physicians of the society be desired to be present at the operation to be performed on the Saturday following, the 23d instant about ten or eleven of the clock in the morning, at Arundel-house; and that Dr. Lower and Dr. King particularly should be desired to manage the experiment; who were desired accordingly, and undertook the operation" (Birch's *History of the Royal Society*, II, 214–15). The experiment took place on the date arranged and, according to Birch, at the meeting of November 28: "Mr. Coga, the first person in England, on whom the experiment of transfusion was made on the 23d instant, by order of the society, and by the management of Dr. Lower and Dr. King, according to the method brought in by the latter, Octob. 24, 1667, and entered in the register-book, presented himself before the society, and produced a Latin paper of his own, giving an account of what he had observed in himself since he underwent the said experiment: which was ordered to be filed up, and Dr. Lower and Dr. King were desired to give in their accounts of the experiment. It was ordered likewise, that Mr. Coga being willing to have the experiment repeated on him, it should be tried again accordingly, when the physicians of the society should judge it seasonable."

The subject of this remarkable experiment, Arthur Coga, is said to have been formerly a student in Cambridge. Oldenburg said that he was a B.D. of Cambridge, that he was regarded as "a very freakish and extravagant man" and that he was "indigent"; King gave Coga's age as about thirty-two, stated that he spoke Latin well and that he liked company, and added that "his brain was sometimes a little too warm". During the operation Coga "made not the least complaint": after it, he was "well and merry, and drank a glass or two of Canary, and took a pipe of tobacco". When asked why he had not had the blood of some creature other than a sheep transfused into him, he replied: "Sanguis ovis symbolicam quandam facultatem habet cum sanguine Christi, quia Christus est agnus Dei."

However, after the operation, Coga addressed the following letter to the Royal Society (see K. J. Franklin,* A facsimile edition of Lower's *Tractatus de Corde*, in *Early Science in Oxford*, IX, Oxford, 1932, pp. xxiii–xxiv):

"*To the Royal Society the* Virtuosi, *and all the Honourable Members of it, the Humble Address of* Agnus Coga.

"Your Creature (for he was his own man till your Experiment transform'd him into another *species*) amongst those many alterations he finds in his condition, which he thinks himself oblig'd to represent them, finds a decay in his purse as well as his body, and to recruit his spirits is forc'd to forfeit his nerves, for so is money as well in peace as warre. 'Tis very miserable, that the want of natural heat should rob him of his artificial too: But such is his case; to repair his own ruines, (yours, because made by you) he pawns his cloaths, and dearly purchases your sheeps blood with the loss of his own wooll. In this sheep-wrack'd vessel of his, like that of *Argos*, he addresses himself to you for the Golden Fleece. For he thinks it requisite to your Honours, as perfect Metaplasts, to transform him without as well as within. If you oblige him in this, he hath more blood still at your service, provided it may be his own, that it may be the nobler sacrifice.

The meanest of your Flock,
Agnus Coga."

Pepys saw Coga on November 30, a week after the experiment; after attending the anniversary meeting of the Royal Society held on that day, when, as we have mentioned earlier, he recorded "that he was near being chosen of the Council", he adjourned with others of the Fellows to dinner, and sat next to Wilkins. "But here, above all," added Pepys, "I was pleased to see the person who had his blood taken out. He speaks well, and did this day give the Society a relation thereof in Latin, saying that he finds himself much better since, and as a new man, but he is cracked a little in his head, though he speaks very reasonably, and very well. He had but 20*s*. for his suffering it, and is to have the same tried again upon him: the first sound man that ever had it tried on him in England, and but one that we hear of in France, which was a porter hired by the virtuosos."

* Professor Franklin (*op. cit.*, p. xxiii) states that Coga was variously described as a "harmless lunatic" and an "eccentric scholar".

Cornelis van Drebbel

On March 14, 1662, Pepys recorded: "In the afternoon came the German Dr. Kuffler, to discourse with us about his engine to blow up ships. We doubted not the matter of fact, it being tried in Cromwell's time, but the safety of carrying them in ships; but he do tell us, that when he comes to tell the King his secret (for none but the Kings, successively, and their heirs must know it), it will appear to be of no danger at all. We concluded nothing; but shall discourse with the Duke of York to-morrow about it." Kuffler was the son-in-law of Cornelis van Drebbel (1572–1634), an ingenious Dutch inventor, who had lived in London during the later years of his life. Kuffler and Drebbel's son, Jacob, wanted the elder Drebbel's secret tested, claiming that it showed how to sink or destroy a ship in a moment: they preferred to sell it to England and they sought a recompense of £10,000. Drebbel had also claimed that he had contrived a vessel that would go under water, the mariners being supplied for breathing by an essence of which he had the secret.

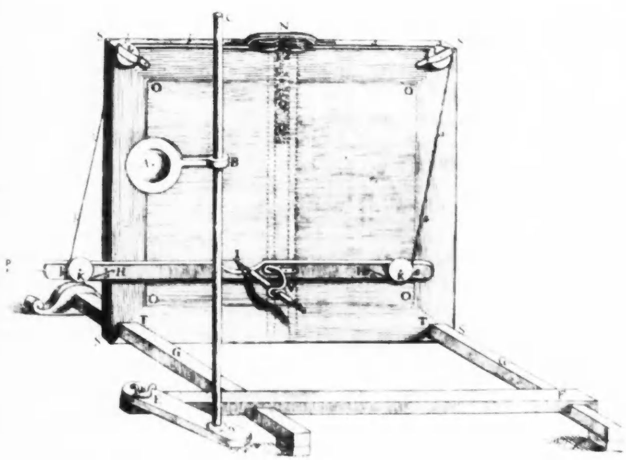
Boyle had been much interested in Drebbel's statement, but, so far as he had been able to inform himself by inquiries conducted after Drebbel's death, the latter thought that it was not the whole of the air, but only a certain quintessence of spirituous part of it that made it fit for respiration, and that, when this part was spent, the remainder was "unable to cherish the vitall flame residing in the heart", whence he used, or proposed to use, a "Chymicall liquor, which he accounted the chief Secret of his submarine Navigation", unstopping its container when the finer and purer part of the air was consumed or "overclogg'd" by the respiration and "steams" of the crew and thus speedily restoring to the air the vital parts necessary to make it once again respirable for a time.

Next year, on November 11, Pepys still recalled Drebbel; for on that day he wrote: ". . . with Dr. Allen some good discourse about physique and chymistry. And among other things, I telling him what Dribble [Drebbel] the German doctor do offer of an instrument to sink ships; he tells me that which is more strange, that something made of gold, which they call in chymistry *Aurum fulminans* [i.e. fulminating gold], a grain, I think he said, of it put into a silver spoon and fired, will give a blow like a musquett, and strike a hole through the spoon downward, without the least force upward; and this he can make a cheaper experiment of, he says, with iron prepared."

Wilkins's "Real Character"

Pepys, as is well known, wrote his diary in shorthand (Shelton's system of 1620), regarded as a kind of cipher. There were several systems in his time; and 'cipher' or 'character' was a subject of wide interest and the making of systems a popular occupation. When he was clerk of Downing, for instance, Pepys had on one occasion to prepare three 'characters' or ciphers. Wilkins, however, proposed something greater, a 'universal character' or 'philosophical language', in which the signs had a phonetic significance and were to be universal. Pepys talked several times with Wilkins on this subject and bought a copy of the "Real Character" on May 15, 1668, which his boy read to him on various dates: he recorded on December 1, 1668, that it "do please me mightily". Perhaps the most interesting entry in the diary relating to Wilkins's work is that under June 4, 1666, where he records: ". . . with Mr. Hooke to my house and there lent some of my tables of naval matters, the names of rigging and the timbers about a ship, in order to Dr. Wilkins' book coming out about the Universal Language". The book was Wilkins's *Essay towards a Real Character and a Philosophical Language* (London, 1668): a valuable study of this work has been published by Professor E. N. da C. Andrade (*Annals of Science*, 1936, *1*, 4).

Much more might be said of Pepys's lively interest in all scientific matters in the long period not covered by the sources studied in this article. It may suffice to say that the creator of British naval organisation maintained that interest throughout the rest of his life, even after his enforced retirement through the turn of politics from the great office in which he had distinguished himself and won the respect of his generation.



Wren's "*Instrument invented divers years ago . . . for drawing the Out-lines of any Object in perspective*", as Wren described it in *Phil. Trans.*, Vol. 4 of 1669:

"The sight *A* is adjustable by means of the rotating arm *B* and the screw *E*. The paper *OOOO* is stuck 'with a little wax' to the frame *SSSS*. The pen *I*, fixed to the ruler *HH*, presses against the paper. By means of the arrangement of pulleys *KK*, *LL*, *MM*, and strings *aaa* and *bbb*, together with the attached counter-weight *QQ*, the ruler *HH* always moves horizontally or parallel to itself.

"The manner of Using it is this: Set the *Instrument* on a Table, and fix the *Sight A*, at what height above the Table, and at what distance from the Frame *SSSS*, you please. Then, looking through the Sight *A*, and holding the Pen *I*, in your hand, move the Head of the Pin *P*, up and down the Out-lines of the Object, and the point *I*, will describe on the Paper *OOOO*, the Shape of the Object so trac'd."

The Battle Against Trypanosomes

GEOFFREY LAPAGE, M.D., M.A., M.Sc.

TRYPANOSOMES, some species of which inflict upon man and domesticated animals incalculable burdens of death and misery, are found in the fluid part of the blood or in the lymph or other tissues of backboned animals. Trypanosomes that live in the blood of cold-blooded fishes, amphibia and reptiles are transmitted to them by leeches and are, so far as we know, harmless to their vertebrate hosts. Trypanosomes that live in the blood and other tissues of man and other warm-blooded animals are transmitted to them by blood-sucking tsetse flies, horseflies, stable flies and bugs and are either harmless to their hosts, as those present in African antelope and other wild game are, or they cause serious diseases that often end in the death of the host, as some species that live in man and domesticated animals may do. Here I propose to concern myself only with the trypanosomes that cause diseases of man and domesticated animals. The best name for all these diseases is *trypanosomiasis*.

The human disease caused by trypanosomes is often called 'sleeping sickness', but this name may cause confusion with an entirely different human disease often called 'sleepy sickness' (*encephalitis lethargica*). The diseases caused by various kinds of trypanosomes in domesticated animals are given different names—e.g. nagana, surra, dourine, mal de Caderas, according to the species of trypanosome that causes them. The main features of trypanosomiasis are anaemia, and enlargement of the lymphatic tissues of the host's body and of the liver and spleen. In the latter stages of the human disease, the trypanosomes get into the central nervous system and cause the lethargy and sleepiness of 'sleeping sickness'.

Trypanosomes may be transmitted to the backboned host by two methods:

(1) The insect sucks up the trypanosomes from the blood and, in the intestine of the insect, the trypanosomes undergo a series of changes, and multiply their numbers. The result of these changes is a form of the trypanosome (called its *infective phase*) that can infect a new host when the insect again sucks blood. Until this stage in the life cycle is reached the insect cannot infect a new host with trypanosomes; normally it takes about twenty to thirty days to reach this stage. This method of transmission, involving a cycle of changes inside the insect, is called *cyclical transmission*. It is the usual method of transmission of the trypanosomes that cause diseases of man and wild and domesticated animals in Africa, although these trypanosomes may also be transmitted by the second method.

(2) The insect may suck up trypanosomes from the blood of the vertebrate host, and may then, within the next few minutes, while its proboscis is still wet and some trypanosomes are still alive on it, bite another host and may directly inoculate trypanosomes into the second animal bitten. The insect thus acts purely mechanically, just as a needle might. This method is called *mechanical transmission*. The trypanosomes that cause diseases of man and domesticated animals in Africa may thus be transmitted by tsetse flies, stable flies and horseflies. It may happen, for instance, that a group of negroes, pushing off from the wooded shores of a lake or river in canoes, are followed by a swarm of tsetse flies and an infected fly may bite and begin to suck blood from a negro infected with trypanosomes. If its meal is then disturbed, it may immediately bite another negro and so transmit the trypanosomes to him.

Outside Africa species of trypanosomes that cause diseases of domesticated animals, such as *Trypanosoma equinum* and *T. evansi*, are transmitted entirely in this mechanical way, not by tsetse flies (which are confined to Africa) but by horseflies and stable flies; and they cannot go through any cycle of development in these flies, nor in any other kind of blood-sucking insect.

The accompanying table shows the trypanosomes that cause serious diseases of man and domesticated animals, together with the insects that transmit them, other modes of transmission and the geographical distribution of the diseases caused. It will be seen that trypanosomiasis is by no means confined to Africa and that the species that cause diseases of domesticated animals are more numerous than those that cause human disease. The latter are important because man depends upon domesticated animals for meat, milk and other products, as well as for transport and for the haulage of agricultural equipment; in addition, domesticated animals have a social and religious value in certain countries. Some experts, in fact, nowadays think that trypanosomiasis of domesticated animals is more important than human trypanosomiasis, because the human disease can, if it is detected early enough, be permanently cured, while it is much more difficult to cure the diseases of domesticated animals and virtually impossible to eradicate them from the wild animals from whose blood the trypanosomes are transmitted to man and domesticated stock.

Control of Trypanosomiasis

The methods used to attack trypanosomiasis seek:

(1) to kill the trypanosomes in man and domesticated animals by means of drugs (chemotherapy); and

(2) to prevent infection of man and animals with them by the bites of the blood-sucking insects that transmit them. This second kind of approach requires detailed knowledge of the biology of these insects. It may be divided into (*a*) attempts to avoid the tsetse flies, stable flies, horseflies and bugs concerned, by the use of chemical insect repellents, screens, etc., or, when tsetse flies are concerned, by removal of whole populations out of their reach; and (*b*) attempts to exterminate the insects or, at least, to limit their numbers.

Chemotherapy

Penicillin and other antibiotics have little action on trypanosomes, or indeed on any other protozoan that causes disease. An ideal drug for the control of trypanosomes should be cheap, because large numbers of men and

A. TRYPANOSOMES CAUSING HUMAN DISEASES

Trypanosome	*Disease and its Distribution*	*Infection*	
		Source	*Mode*
T. gambiense	West and Central African trypanosomiasis in tropical West and equatorial Africa and Congo (also near Lake Tchad, in S. Sudan and on Lake Victoria)	Chiefly other human beings (possibly also some wild and domesticated ungulates)	Chiefly tsetse flies by bite
T. rhodesiense (probably a strain of *T. brucei*)	East African trypanosomiasis in East Africa from S. Rhodesia and Mozambique up to Uganda and inland to Tanganyika and E. Congo	Chiefly wild ungulates	Chiefly tsetse flies by bite
T. cruzi	South American trypanosomiasis chiefly in Brazil but from S. Mexico to N. Argentine and Chile	Many wild animals	Triatomid 'assassin' bugs. Not by bite directly

B. TRYPANOSOMES CAUSING DISEASES IN DOMESTICATED ANIMALS

Trypanosome	*Disease and its Distribution*	*Infection*	
		Source	*Mode*
T. brucei	Tropical African nagana of equines, camels, pigs, dogs, milder in cattle, sheep, goats	Wild ungulates, monkeys (except baboon), dogs, other mammals	Chiefly tsetse flies by bite
T. vivax	Tropical African nagana of cattle, sheep, goats, milder in equines	Wild ungulates	
T. congolense	Tropical African nagana of cattle and other domesticated animals, less severe in camels	Wild ungulates	
T. simiae (*T. suis*)	Tropical African very fatal disease of pigs	Wild ungulates	
T. evansi	Indian surra of equines and dogs; African camel disease in Sudan	Other equines, dogs and camels and possibly some ruminants	Tabanid and stable flies by bite
T. equinum	South American mal de Caderas of horses, milder in mules, sheep, goats	Other equines and possibly some ruminants and capybara	As for *T. evansi*
T. equiperdum	Dourine of equines and dogs in S. Europe, Asia, N. and S. America and S. Africa. Now largely eradicated from temperate climates by prevention of breeding by infected animals	Other equines and dogs	Usually by coitus; occasionally by horse and stable flies

domesticated animals must be treated with it. For the same reason it should be possible to cure with only a single dose of the drug given by the mouth or injected under the skin, which are the two easiest methods of administrating a drug. It should also act on all species of trypanosomes and should be capable of passing from the blood into the central nervous system to kill trypanosomes there. Further, the drug should not have any ill effect upon the host, nor should it create drug-resistant strains of the trypanosomes. (The use of certain drugs has, in fact, produced drug-resistant strains and in man they are commoner than they were 20 years ago, especially in West Africa; but strains resistant to one drug can be killed by giving another drug to which they are not resistant. Quite apart from drug-resistant strains there may be certain strains that are more difficult to kill than others. There are, for instance, at least three different strains of *T. gambiense* that infect man in West Africa. The Nigerian strains of it are more easily controlled by drugs than the Gold Coast ones or those found in Sierra Leone.)

It is quite impossible in a short article to give more than brief notes on the drugs most often used nowadays against the various species of trypanosomes. In the case of one trypanosome, *Trypanosoma cruzi*, no drug is known which will cure the disease to which the organism gives rise; once this disease is well established, it is usually fatal, and control of it must rely on attempts to prevent human beings, especially infants and young children, from being bitten by the bugs that are the vectors. Against other trypanosomes the drugs most often used nowadays are:

Suramin (Bayer 205, germanin, antrypol). This complex urea compound is now generally given mixed with tryparsamide or orsanine, an enhanced effect being obtained when the two drugs are given together, or are administered one after the other. Suramin will eradicate human infections with *T. gambiense* and *T. rhodesiense*, especially if it is given in the early stages of the disease, before the trypanosomes have penetrated into the central nervous system. The cure is then permanent, though re-infection could, of course, occur. In West Africa this drug is given by teams sent out to treat the people, and there it has reduced the incidence of human trypanosomiasis to one-tenth of its former extent. Treatment has been more successful in Nigeria than on the Gold Coast. In Rhodesia it was so successful that natives volunteered for experimental inoculation freely as a way of making money. Strains of the trypanosomes resistant to suramin develop, but these are killed by the tryparsamide given with it. Suramin is also used prophylactically against *T. gambiense* and *T. rhodesiense*, but the organisation required is a drawback to this and the necessary intramuscular injections are painful and have to continue for some five weeks. Moreover, infections that have reached the central nervous system may be left uncured, although tryparsamide of orsanine given with suramin will attack these.

Suramin is effective against, *T. evansi*, *T. equinum* and *T. equiperdum*, but is so poisonous to equines that it cannot be used to treat equines infected with these trypanosomes. It can, however, be used against *T. evansi* in camels and against *T. brucei* in dogs.

Arsenical Drugs

Tryparsamide. The synergistic action of this in combination with suramin has just been mentioned. Another example of this kind of action is the better effect of the two arsenical drugs solusalvarsan and solganol against *T. gambiense* when they are given together. Tryparsamide is effective against *T. gambiense* and less so against *T. rhodesiense* and *T. brucei*. It is valuable because it kills strains of trypanosomes resistant to suramin and especially because it can penetrate into the central nervous system to kill trypanosomes there; but it is especially effective in the early stages of trypanosomiasis, before the trypanosomes have entered the central nervous system. Strains resistant to it develop, but these are killed by suramin. Major drawbacks of tryparsamide are that it may cause optic neuritis and blindness and that treatment must be continued for weeks, although, by combination of it with suramin, the duration of treatment can be reduced to twenty days.

Orsanine (Fourneaux 270). This French product, related to tryparsamide, is preferred by some experts. It acts more slowly, but can cure patients with early implication of the central nervous system. It cured 90% of human patients in the Gambia area.

Atoxyl (soamin sodium), the widespread use of which caused the development of arsenic-resistant strains of trypanosomes, has now been replaced by the three drugs just mentioned.

Neocryl is as effective as tryparsamide in early infections and is less likely to cause optic neuritis, but it is less effective when the central nervous system is involved.

Triazine arsenious acid in the form of melarsen and its oxide and the less toxic 'Mel B' kills trypanosomes quickly in the blood as azoarsenobenzol 4197 also does.

Butarsen removes trypanosomes from the blood in fifteen to forty-five minutes in 98% of patients and has little toxicity to early infections. It can kill *T. gambiense* and

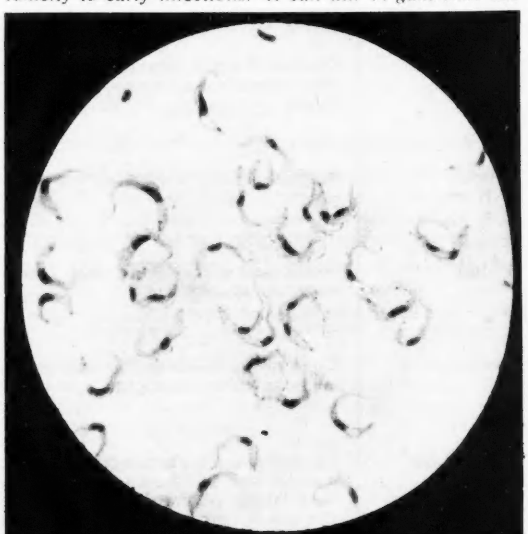


FIG. 1.—Trypanosomes under the microscope. Trypanosomes range in length from about 10 to 30 microns (a micron is one-thousandth of a millimetre).

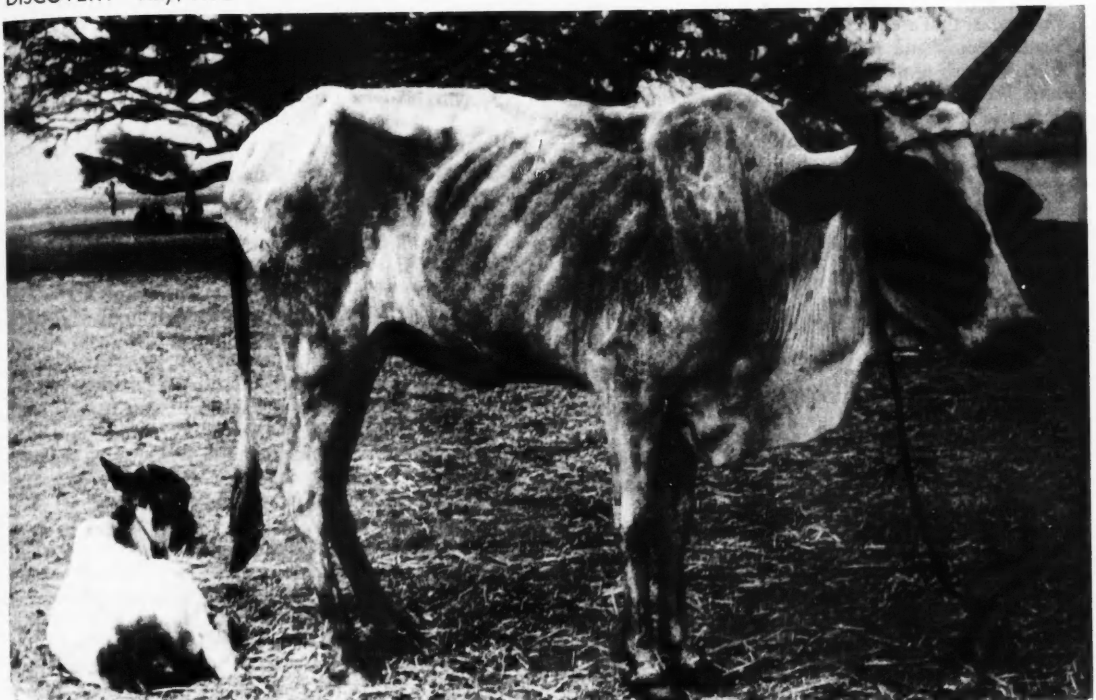


FIG. 2.—Trypanosome diseases in human beings have been brought largely under control. But trypanosomes still upset the economy of the African continent, by affecting domesticated animals. This photo, taken in the Sudan, shows a cow sick with trypanosomiasis.

FIG. 3 (*left*).—In Africa animal trypanosomiasis occurs over an area of four and a half million square miles—75 times the area of Great Britain. FIG. 4 (*right*).—Injecting a sick cow with Antrycide.

T. rhodesiense that are resistant to arsenic and is also useful against *T. evansi* and *T. equiperdum*.

BAL (British Anti-Lewisite), discovered during the Second World War by research workers seeking an antidote to arsenical poisoning resulting from gas-warfare, and the more recent *BAL-OXO*, will protect man against arsenic in trypanocidal drugs, but cannot be used to protect patients treated for trypanosomiasis, because it reduces considerably the action of the arsenical drugs on the trypanosomes.

Antimony Preparations

Tartar emetic is cheap and is effective against *T. congolense*, *T. vivax* and *T. brucei* and it will save the lives of cattle infected with these species and will cure them; but cure is not always effected and its effects are not reliable. For human infections it is used chiefly to reinforce tryparsamide when patients are infected also with blood-flukes (*Schistosoma*).

Antimosan and the compounds related to it are too expensive to be used against trypanosomes in domesticated animals, although they are less toxic than tartar emetic and can be given subcutaneously, which is an advantage; but the labour involved in the necessary repetition of the doses and the cost of the drugs prevent their use for the treatment of cattle. They have, however, been used against *T. congolense* in horses and dogs and, combined with suramin, against *T. brucei* in horses.

Phenanthridinium Compounds

These compounds awakened great interest, because they were effective for the treatment of cattle infected with the dangerous *T. congolense*. The most useful of them are *dimidium bromide* and the more soluble *dimidium chloride*. The former will cure the majority of cattle infected with *T. congolense* and make it possible to keep cattle in areas infected by tsetse flies. There may, however, be large swellings at the sites of the injections of the drug and these may set the owner of the cattle against it. This drug will also convert fatal infections of cattle with *T. congolense* and *T. vivax* into non-fatal ones, and after several years the cattle may become tolerant of these trypanosomes. Dimidium bromide is also effective against *T. simiae*, which is so highly fatal to pigs, but it is not effective against *T. brucei* or *T. evansi*. Some phenanthridinium compounds will, however, kill arsenic-resistant strains of *T. brucei*.

Diamidines (Stilbamidine, Propamidine, Pentamidine). The most useful of these is pentamidine, which is regarded by some experts as being as good as, or better than, tryparsamide for the treatment of human infections with both *T. gambiense* and *T. rhodesiense*. It is the least toxic of the three diamidines mentioned above. There is general agreement that it is as good as suramin. It can be given daily and treatment with it for seven to ten days is sufficient, whereas suramin must be given for five weeks. For this reason it may be preferred, although some patients may find it less convenient to go daily for treatment than to go once a week for suramin treatment. For prophylactic use, its chief value is to protect whole communities and to prevent the infection of tsetse flies, and it is now being used as a routine measure in French West Africa, Nigeria, Sierra Leone and equatorial Africa. In the Belgian Congo propamidine is also used for early human infections. For cattle infected with *T. congolense* the diamidines are too toxic.

Antrycide

The effects of this new drug raised the hope that at last a cure for trypanosomiasis of domesticated animals had been found. The drug has several advantages. It can be given subcutaneously, so that administration of it to large numbers of animals is relatively easy, its toxicity is low and a single dose of it cured African cattle infected with four strains of *T. congolense* and two (possibly three) of *T. vivax*. It also seemed to cure camels infected with *T. evansi*, and equines and dogs infected with *T. brucei*. It is also effective against *T. simiae* in pigs and there is a hope that it will cure infections of horses with *T. equinum* and *T. equiperdum*. Strains of *T. congolense*, *T. vivax* and *T. simiae* resistant to it have, however, developed, and this fact lessens the value of the drug. Another advantage of it is its prophylactic value. A single dose of it will protect cattle against infection with *T. congolense* and *T. vivax* for four to seven months. Recently, however, trials of it have shown that this happens only when the infection does not exceed a certain degree. When, for instance, infection is comparatively light, as it may be when cattle are exposed to a riverine species (see below) of tsetse fly, one injection of antrycide will protect them from death or infection for three months, and cattle left unprotected by this dose are protected by later injections. When, however, the infection is heavy, as it may be when cattle are exposed to an average infection carried by the non-riverine tsetse fly *Glossina morsitans*, treatment every three months cannot be relied upon to protect the cattle from death or infection, and strains of the trypanosomes resistant to antrycide may then develop. Antrycide is far more effective than other drugs used for the treatment of trypanosomiasis of domesticated animals, but the development of strains resistant to it is a serious drawback.

These brief notes on the drugs nowadays used show that although human trypanosomiasis can, with the exception of the disease caused by *T. cruzi* in South America, be successfully treated so that permanent cures are obtained, provided that re-infection does not occur, treatment of the disease in domesticated animals is less satisfactory. Treatment of human trypanosomiasis may be either treatment of individuals or mass treatment of whole communities. The latter can reduce epidemics to a level that can be dealt with by chemotherapy, but it cannot eradicate human trypanosomiasis from large communities. Workers in the Belgian Congo have, however, claimed that they have eradicated the disease from a population of 100,000 people, among whom no case has occurred since 1927, although the tsetse flies are as numerous as ever. Similar claims have been made in the Cameroons. Elsewhere, however, eradication has not been achieved by chemotherapy. In any event, drug-treatment cannot affect the tsetse flies. It can only reduce the chance of infection of them. The flies remain and re-infection of cured human beings may occur. The only sound, long-term policy is to attack and attempt to exterminate the tsetse flies. This aspect of the problem will be discussed next month.

Enemies of the Oyster

HAROLD BASTIN

We talk glibly of "the harvest of the sea", but in fact the implied analogy is somewhat remote, except, perhaps, when the phrase is used in relation to edible oysters. For of oysters alone among marine comestibles can it be claimed that mankind has cultivated rather than exploited them, if not from time immemorial, at least since the days of classical epicureanism. Hence it is hardly surprising to find in textbooks on the oyster industry allusions to 'farmers', 'seed', 'beds', 'stocking and relaying', 'fattening grounds' and so forth—terms perfectly familiar to the husbandman in his special capacity as tiller of the soil and raiser of flocks and herds. Moreover, we learn from the same source that oysters, like cattle and crops, are exposed to the attacks of numerous enemies or 'pests' which, if they cannot be completely eradicated, must needs be unremittingly controlled if serious financial loss is to be avoided.

Experts agree that oysters are remarkably free from such obvious parasitic diseases as can be detected with the naked eye or by the aid of the microscope. Also, in case of need, these lowly organisms are able to excise large portions of their anatomy without serious consequences, thus ridding themselves of morbid growths or harmful invading substances.

Yet during the period immediately following the First World War an epidemic malady spread among British oysters. The cause of this outbreak remains mysterious, but the stocks suffered devastating depletion from which they have not yet fully recovered. Furthermore, infant mortality among oysters has always been phenomenally high. A single adult may produce any number from several hundred thousand to more than a million offspring. But as soon as these escape as free-swimming larvae from the parent's mantle the vast majority becomes food for the hosts of plankton-feeders, including the young of many fishes, such as herrings and sprats. Precise estimates are not available, but probably nine-tenths or more are thus disposed of before—after an interval of from ten to fourteen days—the survivors settle as 'spat', anchor themselves to any suitable surface, and with luck grow in the course of the next four or five years to marketable size.

Obviously the oyster-farmer is powerless to abate this massacre of the innocents; but from spat-fall onward he can do something to mitigate the ravages caused by crabs, barnacles, sundry molluscs and other pests which frequent his beds. Most of these may be roughly classified under two headings: firstly, those whose natural prey includes oysters, and secondly, those that compete with oysters for the organic particles floating in the water—the 'sea dust', as it has been called—which form their common food.

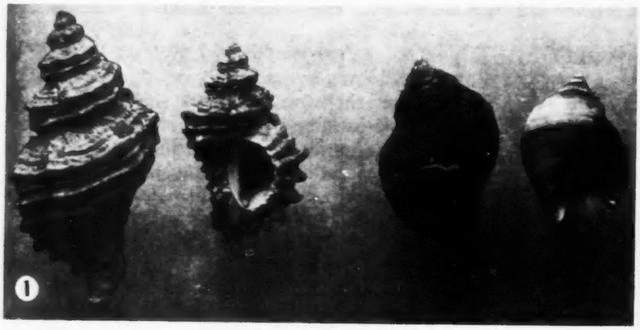
The ubiquitous green shore crab (*Carcinus maenas*) usually attacks young oysters, but will also destroy older ones which are backward in development or of weak constitution. Its method is first to break away the thin, newly deposited layer of shell round the edge of the valves, afterwards inserting the tip of its large claw through the breach to extract the meat.

Tradition has it that the common starfish (*Asterias rubens*) pulls open the valves of oysters' shells by means of the strongly cohesive tube-feet clustered on the underside of its rays or arms, and then everts its stomach over the prey, which is ingested at leisure. But the present writer is informed by Mr. Duncan Waught, scientific officer of the Ministry of Agriculture and Fisheries research station at Burnham-on-Crouch (where the oyster is under investigation), that this needs confirmation. In a recent experiment when a large and presumably hungry starfish was given every encouragement to operate on an oyster it made no response. On the other hand, it subsequently opened and consumed a mussel quite readily.

More destructive than any other carnivorous pests are the 'sea snails', known to longshore folk as 'tingles' or 'drills', which bore neat, circular holes in the shells of bivalves and so manage to get at the soft contents with their toothed tongues, or *radulae*. These are three in number: the 'sting winkle' or 'English rough tingle' (*Ocenebra*=*Murex erinacea*), the 'dog whelk' or 'English smooth tingle' (*Nucella*=*Purpura lapillus*), and—worst of all—the 'American rough tingle' (*Urosalpinx cinerea*). The last-named was inadvertently brought from the other side of the Atlantic with imported oysters about the beginning of the present century, since when it has multiplied prodigiously, especially in the Thames Estuary, where in some seasons it has destroyed up to 50% of the spat-fall. Dr. J. H. Orton states that it can drill the shell of a sizable oyster and devour the occupant in from three to six days, while its pertinacity is such that when, in an experiment, one in the act of boring was removed a short distance from its victim and laid wrong side up, it quickly righted itself and returned four times in succession—"like a dog to a bone"!

At present only palliative measures can be employed in combating these pests. Crabs, starfish and tingles, together with the characteristic and easily recognisable egg-capsules of the last-named, should be sedulously collected from dredgings and brought ashore to be destroyed. In most districts a bonus is given to dredger-men to encourage this practice. In former years in the Thames Estuary, starfishes were regularly dredged and sold for manure, but this practice has long since been discontinued, probably because it ceased to be profitable. Hand-picking on the shore, when this can be organised, serves to reduce the numbers of the miscreants, but many are bound to escape, and no method calculated to eliminate this menace from the oyster beds has been devised.

Many kinds of sedentary animals—hydroids, tube-worms, sea-squirts and others—are inimical to the well-being of oysters, settling as they do on the same type of surface as the oyster favours and feeding on the same sort of food. Mussels sometimes settle in vast numbers on oyster grounds and if unmolested soon form beds of their own. But more harmful than any of these is the slipper- or bonnet-limpet (*Crepidula fornicata*) which not only robs oysters of their nutriment but also tends to smother them under its rapid increase. Like the American oyster drill,



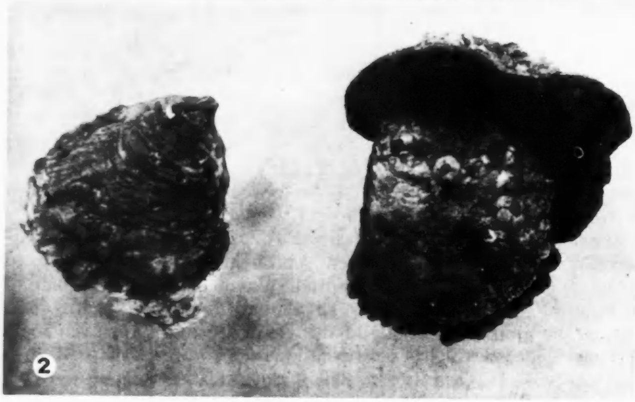


FIG. 1.—Shells of two species of sea snails are shown in this photo; the two shells on the left belong to the species called *Ocenebra erinacea*, the others to *Nucella lapillus*. The longshoreman's names for them are, respectively, 'Rough Tingle' and 'Smooth Tingle'.

FIG. 2.—Young oyster-shells showing holes bored by the American Rough Tingle (*Urosalpinx cinerea*).

FIG. 3.—The Bonnet-limpet (*Crepidula fornicata*).

than which it is scarcely less injurious, it came to us as an accidental importation from the New World, and was first observed on our coasts in the eighteen-eighties. Despite its popular name and the form of its shell it is more nearly related to the periwinkles than the limpets, but is much more stay-at-home than either, with the curious habit of living in piles ('bungalows' is the oyster-man's term), one individual mounting upon the back of another to the number, it may be, of ten to twelve. The lowest in the pile, resting directly on a rock or an oyster, is invariably a female, but at a later stage the youngest and uppermost will be found to be males, while hermaphrodites often occur in between. To breathe and to feed, the edge of the shell is slightly raised and a current of water drawn through the ciliated gills. Hence, the animal has no need to move about. Moreover, since the pile as it multiplies tends to form a short spiral bending over to the right, the edges of all the shells are brought close together, and the males can pair readily with the females nearest to them. To rid oyster beds of this pest is fairly easy though somewhat expensive. After dredging, the catch is crushed, shells and all, and returned to the water, which is thereby enriched with phosphates and nitrates.

Barnacles also feed and breathe after the same fashion as oysters, which they thus tend to starve and smother when they are present in vast numbers, as is frequently the case. The recently introduced New Zealand barnacle (*Elminius modestus*) is becoming increasingly abundant, its numbers on the east coast oyster beds exceeding those of the native acorn barnacle (*Balanus balanoides*). The alien species, originally collected and named by Charles Darwin, is common in estuaries in New Zealand and South Australia, and is believed to have been brought to European waters attached to the hulls of ships, probably by way of the Panama Canal. Specimens were first noticed in Colchester harbour, from which it has spread along the coast in both directions to Norfolk and Cornwall.

So far no method has been devised for ridding oyster beds of these pests; but in some years sea-urchins—or 'burrs'—mitigate the nuisance by browsing the shells clean, not only of barnacles, but also of worm-tubes and similar incrustations. Unfortunately they are apt later to rasp away at the oysters' shells, rendering them thin and easily broken.

The most harmful shell-destroying organism, however, is the burrowing sponge (*Cliona celata*). This makes ramifying tunnels in the walls of the oyster's stronghold, these being filled with living material which bulges from the surface at intervals as small, yellowish cushions. No practical remedy is known; but as far as possible all infested shells should be removed from the beds and destroyed.

Some of the larger seaweeds, such as oar weeds (*Laminaria saccharina* and *L. digitalis*), and boot-lace weed (*Chorda filum*), if they fix their root-like hold-fasts to oysters, may drag them into deep water in rough weather, or float and carry them away. But these are only minor enemies, unlikely to cause loss, save in exceptional circumstances.

Far and Near

An Astronomical Work by Chaucer?

A MANUSCRIPT written in 1392 and entitled "The Equatorie of the Planetis" was recently discovered in the archives of Peterhouse College, Cambridge. This document has been carefully examined by Dr. Derek J. Price, who is convinced that it was written by none other than Geoffrey Chaucer. This manuscript attracted much attention when it was shown to the scientific world for the first time at the Royal Society conversazione on May 22, although not all historians of science who have seen it are prepared to accept the claim that it is a Chaucerian manuscript. Dr. Price is now engaged in writing a full account of his investigations, about which he has written a preliminary report for the *Times Literary Supplement* (Feb. 29 and March 7 issues, 1952).

Another interesting exhibit at the Royal Society conversazione was concerned with the preparation of cortisone from a chemical compound present in the sisal plant. Since the discovery of the remarkable properties of cortisone in the treatment of rheumatoid arthritis a world-wide search for a commercial source of supply has been carried out. The National Institute for Medical Research demonstrates how the sisal plant grown in large quantities in Tanganyika and Kenya can yield an extract called *hecogenin* from which the chemist can make a comparatively simple partial synthesis to produce cortisone and other adrenal cortex hormones.

A Hundred Alchemical Books

THE Science Museum has embarked upon a series of special exhibitions of historic books and documents relative to science and technology. The first of these, which opened on June 25, is entitled "A Hundred Alchemical Books". Alchemy, the art which aimed to transmute base metals into noble, was the forerunner of chemistry, and contributed to it many laboratory techniques, and, indeed, the very concept of the laboratory itself. Hardly any material relics of alchemy have survived and the subject is therefore one to be most fittingly presented by an exhibition of books.

The majority of alchemical books are finely illustrated not only with pictures of alchemical apparatus and laboratories, but also with the strange and beautiful symbols in terms of which the alchemists understood nature and their art. These symbolic pictures have for some years attracted the interest of the psychologists, especially of the school of C. G. Jung.

The books in this collection, a number of which are of extreme rarity, have been drawn mainly from the Science Library, but many of the finest items come from the library of the Museum of the History of Science, Oxford, including the loan collection of H.S.H. Prince von Knyphausen, from the collection of Mr. G. Heym, and from a few other donors, private and public. Some modern books on the subject are also included.

The exhibition will remain open to the public until September of this year.

* * *

The exhibition, arranged by the British Horological Institute to display several hundred clocks, watches and marine chronometers of historic interest, will remain open at the Science Museum until September 14. The relevant catalogue, which is entitled "British Clockmakers' Heritage Exhibition", can be purchased through any branch of the Stationery Office, or at the Science Museum.

Prince de Broglie Awarded Unesco Science Writing Prize

THE Kalinga prize for the best work in the field of popularisation of science was presented, on May 28, to Prince Louis de Broglie, by Torres Bodet, Director-General of Unesco, in a ceremony at Unesco House in Paris. The world-famous French scientist, who won the Nobel Prize in 1929, is the first recipient of the prize which is worth one thousand pounds. The ceremony at Unesco House took place in the presence of Mr. M. B. Patnaik, a leading Indian industrialist, who established the award last year under the auspices of Unesco as a means of focusing attention on the need for greater understanding and broader use of science for human welfare.

Prince de Broglie is internationally famous both for research in theoretical physics and for pioneer achievements in the popularisation of science. He is the honorary president of the French Association of Science Writers and the permanent secretary of the French Academy of Science.

The jury for the 1952 Kalinga award had three members: Dr. Göran Liljenstrand of the Caroline Institute in Stockholm; Dr. M. N. Saha, F.R.S., Professor of Physics at the University of Calcutta; and M. Paul Gaultier, member of the Institut de France. They represented, respectively, the biological and physical sciences and the reading public.

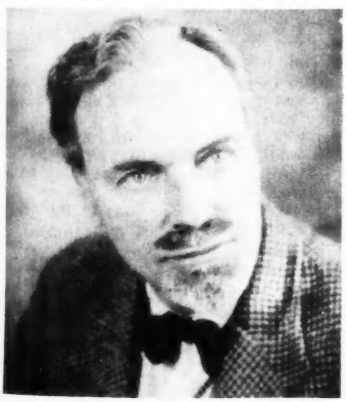
In making their choice the jury considered ten candidates nominated by scientific organisations in Austria, France, India, the Netherlands, New Zealand, South Africa and Britain.

High-altitude Laboratories

LAST year (in the March 1951 issue, pp. 70–73) we published an illustrated description of the scientific activities in train at the Jungfraujoch research station which is one of the world's most important high-altitude laboratories. This laboratory is situated 11,300 feet up the Jungfrau, and there is a meteorological observatory 400 feet above it. It is, however, not the highest laboratory in the world. An article in *Physics Today* (May 1952) lists nineteen high-altitude laboratories scattered throughout the world, and four of them are at heights well above that of the Jungfraujoch station. The highest one (18,000 feet) is Chacaltya, in Bolivia. India is planning a high-altitude laboratory, at 16–17,000 feet, and Pakistan intends to establish a similar station at 14–15,000 feet.

Catalogues of Science Books

LATEST catalogue issued by H. K. Lewis & Co. Ltd. of Gower Street, London, W.C.1., provides useful lists of books



(Right) H. G. DAVEY, M.SC., *who has been largely responsible for bringing the Sellafield plutonium plant into production, received an O.B.E. in the Queen's Birthday Honours List. He started his career as lecturer on chemical engineering at Glamorgan Technical College. During the war he was a shift chemist at the Royal Ordnance Factory, Pembrey, later transferring to Drigg R.O.F. to become managing chemist and later superintendent. He is now Works General Manager at the Sellafield atomic factory, otherwise known as the Windscale Works.*

(Left) *The B.B.C. has appointed* C. L. BOLTZ *as staff science correspondent with the Overseas Service. His predecessor was the late Clifford Troke. Mr. Boltz, who has been a regular contributor to* DISCOVERY, *was on the staff of Finsbury Technical College for a long time. During the war years at Finsbury he trained many radar operators for the Army. Recently he has been a demonstrator at Birkbeck College. He is the author of a number of science books, his latest work being the collection of popular essays entitled* A Statue to Mr. Trattles.

dealing with the following subjects: Agriculture; Tropical Agriculture; Horticulture; Forestry; Animal Husbandry; Veterinary Science; Dairying and Fisheries. This catalogue will be sent free on application. Also available are six other catalogues which deal respectively with the following fields of science and technology: Biological Sciences; Chemistry; Chemical Industry; Electrical Engineering, Radio and Electronics; Geology, Mineralogy and Mining; Mathematics, Physics, Astronomy and Meteorology.

Register of Biological Consultants

THE Institute of Biology has recently established a Register of Biological Consultants and is now in a position to recommend specialist advisers in any branch of the biological sciences. Inquiries should be addressed to the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

Industrial Television Equipment

AT the recent Television Convention a novel piece of portable equipment was demonstrated by Pye Radio Ltd. This consists of a miniature camera on a tripod and a combined control unit and monitor tube unit. The two units are exceedingly compact and weigh less than 100 lb. The camera can be operated at distances up to 300 yards from the control unit, to which it is connected by a multi-core cable.

The equipment provides a new and highly efficient means of observing any industrial process or research operation where direct observation would be impracticable or harmful to the observer. The large screen of the monitor tube also enables the operation to be seen by a number of observers at once.

A choice of three scanning systems is available: 405, 525 or 625 lines, interlaced, and the camera is fitted with a 3-lens turret giving focal lengths of 1, 2 or 3 in. It employs a pick-up tube 1 inch in diameter requiring a scene brightness of 50-ft. candles.

During the demonstration the camera was 'panned' on the lighted signs in Piccadilly Circus, which came out clearly on the monitor screen.

Night Sky in July

The Moon.—Full moon occurs on July 7d 12h 33m, U.T., and new moon on July 21d 23h 30m. The following conjunctions with the moon take place:

July				
2d 16h	Mars in conjunction with the moon		Mars	4° N.
16d 04h	Jupiter	,,	Jupiter	7° S.
24d 04h	Mercury	,,	Mercury	2° S.
28d 04h	Saturn	,,	Saturn	7° N.
30d 19h	Mars	,,	Mars	4° N.

The Planets.—Mercury is an evening star, setting at 21h 40m, 21h 10m and 20h at the beginning, middle and end of the month respectively and can be seen in the western sky after sunset, stellar magnitude varying from 0 to 1·6. Venus is an evening star but sets too soon after the sun for good observation. Mars, an evening star, sets at 0h 10m, 23h 25m and 22h 35m on July 1, 15 and 31 respectively, its stellar magnitude varying between −0·5 and 0; towards the end of the month it is a little south of α Librae. Jupiter can be seen in the early morning hours, rising at 0h 50m, 23h 55m and 23h 16m on July 1, 15 and 31 respectively, stellar magnitude −1·9.

The earth is at its greatest distance from the sun on July 4, this distance then being just over 94½ million miles. Sometimes those who have only an elementary knowledge of astronomical matters are confused by the proximity of this date to that of the longest day, just as they are confused by the proximity of the date of the earth's closest approach to the sun—about January 4—with the shortest day which occurs a few days before Christmas. There is no connexion between these, and the length of the day depends on causes quite different from that responsible for the distance of the earth from the sun.

A conspicuous summer constellation is Corona Borealis—so named because of its resemblance to a crown. If in doubt about its position, remember that it lies almost exactly overhead on July 1 at 21h, and you cannot mistake this beautiful object. There is an interesting story about a new star which suddenly blazed forth in 1866 in this constellation. Before this conflagration it was probably a faint telescopic object which did not attract much attention, and a few hours before its outburst those who were looking at that part of the heavens did not notice anything remarkable. Many theories have been advanced to explain these new stars or novae, but they still present a number of puzzling features to the astronomer.

The Bookshelf

The Origin, Variation, Immunity, and Breeding of Cultivated Plants. Selected writings by N. I. Vavilov, translated from the Russian by K. Starr Chester. (Chronica Botanica, Waltham, Mass., U.S.A.; London, Wm. Dawson, 1951, 364 pp., $7.50, 60*s*.)

THE Russian genetics controversy came to a head in 1940. In that year, Vavilov, who had organised a chain of four hundred experimental stations from Leningrad to Vladivostok, was ousted and his place taken by Lysenko, who is regarded by geneticists in non-communist countries as a plausible charlatan.

This controversy was followed with great interest in this country and in the United States. Now for the first time we have the opportunity of reading what is virtually Vavilov's defence. It contains four essays treating in detail of the origin, variation, immunity to disease and insects of cultivated plants, concluding with a most detailed account of wheat breeding in all possible aspects. The last paragraph of this essay is significant. It reveals Vavilov's ideas about the future of wheat breeding, which also apply with slight modification to other economic crops.

"Modern wheat breeding has only just begun. Now we know more or less completely the initial species and varietal composition of the world wheat potential and have it. There have been discovered a wealth of species . . . unknown to scientific breeders of the past. The study of growth-stages opens up new possibilities in the use of the world resources of wheat varieties. Physiology is approaching an organised evaluation of the world assortment of wheats according to winter-hardiness and drought resistance. Biochemistry is going deeply into an analysis of the protein fraction of wheat. The genetic nature of characters in a majority of species still has not been worked out. The great specific and varietal potentials have still been used only to a limited extent in plant breeding. In order to achieve a solution of this great problem we need sound fundamental theory, and we need the combined work of breeders with geneticists, physiologists, chemists, technologists, phytopathologists, and entomologists."

What Vavilov said ten years ago is still true today. About the majority of economic plants we know virtually nothing, and our ignorance coincides with a headquarters pronunciamento that in the near future there will be in this country a superfluity of biologists.

All these essays are written in masterly fashion, and reveal to the fullest Vavilov's incredible industry, enthusiasm and profound learning, combined with equally profound wisdom. Through them we see that the central core of his philosophy was that the main function of the botanist is to know plants, and then to use his knowledge for the service of mankind.

It is interesting to note the tone of Vavilov's numerous references to the work of Lysenko, one of whose satellites described his views on wheat as "Fascistic". Vavilov always gives full credit to Lysenko for his work on vernalisation, which he regarded as a useful tool for the plant breeder, rather than as a revolutionary discovery in agriculture.

Time has proved him to be right. His further deduction that "the future systematist must be basically a physiologist" may pass unnoticed, but it is one of the gems of botanical wisdom contained in this book, which should be read by all biologists, and by all those who have inquired, "What is the answer to Lysenko?" Here it is—one of the great classics of biology.

S. C. HARLAND.

Water. By Sir Cyril S. Fox, D.Sc., F.G.S. (London, Technical Press Ltd., 1952, 148 pp., 30*s*.)

THIS is a very comprehensive survey of water in all its many geological aspects accompanied by many diagrams, illustrations and tables. Most of this has been

described elsewhere, but in this volume the information is presented simply and clearly. Special mention must be made of Part 3 which covers the utilisation of water, which, although short, contains much useful information and is up to date in outlook and content. F. A. HENSON.

Patrice Periot. By George Duhamel, translated by E. F. Bozman. (London, Dent, 1952, 11*s.* 6*d.*)

THE recent fierce interaction of science and politics has produced a moral whirlpool which has dragged down not a few individual scientists to the distress of everyone connected with the scientific profession. Few scientists have been able to ignore this, and yet in years to come it will probably prove difficult for historians to recapture the troubled atmosphere of this period in which science has had so powerful and uncomfortable an impact upon society that a strong anti-scientific reaction has been set up. Among the records historians will find the accounts of the Nunn May case and the Fuchs case, and there will also be available the official Canadian and U.S. atomic espionage reports. But the historian who wants to get a vivid impression of the emotional context of these episodes will find himself turning to this novel. It brings out the conflict of loyalties which are involved by the device of concentrating on the symptomatic conflict of loyalties that affect one particular scientist. Patrice Periot is a distinguished French biologist, a well-meaning man who is surrounded by Communist associates given to pursuing 'Peace' as though it were some dangerously inoffensive animal that ought to be hunted and killed. He is the familiar figure who declares that he is "first and foremost in the service of pure knowledge" and yet allows himself to get involved in political controversies which he fails to understand because he is altogether too simple, too sincere and too honest. He becomes the tool of cleverer, less scrupulous men who use him to direct the attention and suspicion of the authorities from their own directly political manœuvres. He is in effect their hostage, but a hostage who is paraded on a public platform instead of being locked away in a solitary cell. Finally, he is reduced to the tragic phase when he can no longer live at peace with his own conscience, and the realisation that it is easy to be a vague 'internationalist' who can concern himself with remote beings he need never meet, but far more difficult to live up to one's own closer personal responsibilities, is brought home to him by the tragic death of his son. This novel is as topical as today's newspaper, and it is probably nearer to factual truth than most non-fiction books.

Colour Cinematography. By Major A. Cornwell-Clyne. (London, Chapman & Hall, 1951, 761 pp., 84*s.*)

THIS is the third edition of what is by now the standard work on the subject—the only comprehensive one, in fact, in the English language. The first edition, published in 1936, ran to a modest 335 pages of text; in the present one there are 761 pages and even eight diagrams in colour.

The author's motto seems to be comprehensiveness at all costs: everything relevant that has ever been invented, discovered, or written about the theory and practice of colour motion pictures has apparently been crammed in. There are vast tables of figures, coefficients and co-ordinates; page after page of patent lists and specifications. It is doubtful whether all these tables are worth the space they take up and weight they add to the book, for surely, not even the keenest student can take them all in. The author might perhaps have served his readers better by quoting more of them as references at the ends of chapters. And here lies the book's chief fault; for in trying to combine the functions of a complete reference work and a detailed theoretical text-book, it has acquired a sprawling, rather indigestible, character.

As a work of reference it certainly has great value, giving as it does details of practically all the many and varied processes for making films in colour. But it is not a text-book for beginners. The author, like many others who write technological books, is clearly an absolute past-master of his complex subject, but he is, unfortunately, not so skilful at getting that subject across to others, nor does he marshal his material in the clearest way. In the preface to this latest edition, the present adverse state of the British publishing industry is blamed for the book's untidy final state; yet even in the pre-war editions there was this same odd, slipshod presentation of facts and material, which tended to make a difficult subject even harder.

The present edition certainly has more than its fair share of muddle. One plate, for instance, referred to in the text, is not included at all; it turns up 300-odd pages later, with a different number. Two whole sections of text, each of two or three pages—one on bi-pack and the other on actors' make-up—occur twice; once near the beginning of the book and again, word for word, towards the end. As there is no suggestion that these repetitions are designed to facilitate reference, it can only be assumed that they are coincidental.

The book is perhaps weakest of all when dealing with such matter as the aesthetics of colour films and audience reaction. On page 30 we read: "A two-colour process can in the nature of things only provide a minute proportion of the total range of colour sensations, and the undoubted satisfaction which has apparently been registered by uncritical audiences confirms the belief held by many colour-film experts that the average filmgoer is far less sensitive to the subtleties of colour than had been generally supposed." Yet, on page 661: "To those of us who have had some years' experience of colour films it is a remarkable fact that the introduction of colour into the picture seems to arouse instant criticism from an audience which will tolerate normally any amount of distortion in black-and-white. It would seem as if the normal power of colour identification is very highly developed."

Perhaps the fairest summing-up of this somewhat baffling book is that if read intelligently as a standard reference work, and without expecting too much of it as a fundamental text-book, it can be of great value. The author's painstaking collection of detail must be recognised as remarkable for its completeness.

Geography of Hunger. By Josué de Castro, with a foreword by Lord Boyd Orr. (London, Victor Gollancz, 1952, 260 pp. bibliography and index, 18*s.*)

LORD BOYD ORR in his foreword to this book says that its title might well have been "Hunger and Politics", since political issues of the first magnitude emerge from it.

For many years now Lord Boyd Orr has been warning the world of the dangers of food shortage and as the Great Powers even now jockey for position and advantage for the start of what appears in the not too distant future to be a third world war we would do well to read this book and understand its message.

A vast section of the world's population is grossly underfed both in quality and quantity. By far the greater number of them live in the Middle and Far East and in Africa, but the peoples of these countries are awakening and are beginning to demand social justice, to demand more and better food. If all the food in the world were distributed according to the density of the population there would be seen to be a gross deficiency for all. Coupled with this known shortage of food is the alarming rate of increase of the population of the world, again particularly concentrated in the East. To cope with this, the food supplies of the world must be continually expanded.

The concept of pressure of population upon food supplies is of course far from new. It was first enunciated by Malthus in his *Principles of Population* in 1798. This had a marked effect on public opinion when it first appeared, but the expanding economy of the nineteenth century drew a veil over the dangers which Malthus's thesis seemed to present with such startling clarity in 1798. More recently the Malthusian dangers have reared their heads again, and many people have asked what will happen if hygienic and nutritional levels are substantially raised in these already overpopulated Far Eastern countries—will not population pressure rapidly reach bursting-point and catastrophic nutritional conditions, at least as bad if not worse than they are today, prevail? Josué de Castro says "no". He claims that there is evidence that as the protein content of the diet increases, the birth-rate will decrease. It is certainly a fact that the birthrate is very much less in western countries, but whether the effect is due to the greater amount of protein in the diet it is difficult to say. Nevertheless, the author's evidence should be read and seriously considered. The scope of his book is great. He traces the history of hunger round the world, and in a final chapter gives an account of "The Geography of Abundance". There seems no doubt that the world can produce the food necessary to feed its population, but it is problematical that it can do so for much

longer if it continues to divert its money, its energy, its resources and its brains in preparation for war.

The author of this book is well qualified to write on the subject, since he is chairman of the executive of the Food and Agriculture Organisation of the United Nations. He writes attractively and well, and his book can be recommended from every point of view.

GEOFFREY H. BOURNE.

Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. National Bureau of Standards Handbook 49, iv, 11 pp., 10 cents. (Order from Government Printing Office, Washington 25, D.C., *or* H.M. Stationery Office, P.O. Box 569, London, S.E.1.)

WITH the increasing use of radioactive isotopes by industry, the medical profession and research laboratories, certain minimal precautions must be taken to protect the users and the public. The recommendations in this handbook represent what are believed to be at present the best available opinions on the subject.

While continuous study is being made to eliminate the uncertainty regarding permissible radiation exposure levels, particularly for ingested radioactive materials the handbook gives the soundest figures now known. If, in the future, these figures can be improved upon, appropriate corrections will be issued. The handbook was prepared by the National Committee on Radiation Protection, and the Subcommittee on Waste Disposal and Decontamination of this organisation is carrying on further work in the field.

As the problem of the disposal of radioactive wastes varies over such wide limits, depending upon the usage to which the isotopes are put, the committee has decided to issue individual reports dealing with particular conditions. In the expectation that disposal of the greater part of phosphorus-32 and iodine-131 isotopes will be by sewer, the handbook considers permissible concentrations from the point of view of safety to the general community and more especially to sanitation workers and sewage plant personnel. It contains practical and easily followed rules of disposal practice for specified isotopes.

Mathematics at the Fireside. By G. L. S. Shackle. (London, Cambridge University Press, 1952, 156 pp., 27 diagrams, 16*s*.)

THE author of this little book claims as its purpose "to give quite young people a grasp of that small number of architectonic ideas on which mathematics is founded: such ideas as *correspondence*, *limit*, *reasoning by recurrence*, and so forth". The book consists of a series of conversations between two children, George and Lucy, and George's father; it succeeds fairly well in expressing some of the abstract notions of mathematics in terms of everyday things. Typical chapter headings are "The Beetle and the Tape-Measure", "Making it Easy to Manage Tiny Numbers", "The Secrets of a Fountain Jet" which indicates the general approach and style, while there are many minor brain-waves, such as using the rhyme: "As I was going to St. Ives, I met a man with seven wives; each wife had seven sacks . . ." to explain the concept of a scale of notation. In places, too, the more responsive reader may catch a sudden insight into the strange fascination of the mathematician's inner world. All this must be said in the book's favour.

On the debit side, however, it has its rather obvious faults. Chief among these is a kind of inconsistency most unbecoming in a mathematician. Prof. Shackle, say the publishers, "is at some pains to talk our language". Admirable; but precisely to whom is he talking? The publishers admit they don't really know; but when the author is apparently addressing seven-year-olds, sometimes even delivering them an English lesson—" 'express' means 'write' or 'say' ", " 'contents' means 'what is inside' "—adults or even older children will find his talking down irritating, to say the least; while the seven-year-olds will certainly not appreciate the chapters on the calculus and complex numbers. It is a pity that Prof. Shackle's preoccupation with exposition as such has led to this uneven approach, and to a certain unworldliness; as when he takes us through a whole chapter—and an interesting one, too—on integral calculus with the object of finding the area of a lawn, and arrives at the rather bleak answer

$$A=\int_0^b f\ (x)\ xd.$$

It is the same unworldliness about George and Lucy which makes them so hard to believe in as children; their powers of deduction are breathtaking, and they can remember complicated formulae for several days.

In spite of these faults the book remains an interesting piece of fireside reading. It is attractively presented, and layout and printing are good. The author, to his credit, uses colour symbolically (all his graphs have a red x-axis and a blue y-axis, and lines in other colours are used as well). Colour, used sparingly in a black and white medium, is always an added attraction. For those who can take its inconsistencies in their stride, this book may well prove to be a valuable informal introduction to mathematics.

DENIS SEGALLER.

The Stars in Our Heaven. By Peter Lum. (London, Thames and Hudson, 1952, 243 pp., 18*s*.)

ANYONE who has looked up at Ursa Major and wondered why this constellation, which looks less like a bear than anything, should have earned such a name independently in the New World and the Old, in India, Greece and North America, will be interested by *The Stars in Our Heaven*. In it Peter Lum tells us that when the first white men to land in the great American continent had learned something of the Indian language they pointed to the Great Bear and said what they called it. The Indians, delighted, informed them: "Those are our Bear stars too."

The book contains a fascinating wealth of ancient lore and up-to-date fact about the myriad stars which modern man has come almost to the point of ignoring but which, to our forefathers, were the power that guided the sun and were responsible for its safe conduct through their territory, produced the seasons, controlled the moon and could, had they desired, have destroyed the earth with man and all his handiwork.

In Hindu mythology, we are told, the moon was King Soma, whose twenty-seven star-wives were all so divinely fair that he could not bear to spend more than a night at a time with each. To the Chinese the constellations of the Lunar Zodiac were the 'Sieu', or houses, while the Arabs knew them as the 'Roadside Inns', or resting places of the moon.

The drawings by Anne Marie Jauss, which attempt to help the reader by linking the constellations with their various associated names by superimposition of line sketches, are a disappointment. This may be partly because the outline is too bold, but is more probably due to the fact that they attempt to represent a resemblance that in most cases never existed. This defect is far outweighed by the book's many other qualities, however, and it would earn its keep in any man's bookshelf. L.B.

From Atoms to Stars. By Martin Davidson. (London, Hutchinson's Scientific and Technical Publications, 1952, 280 pp., 18*s*.)

THIS book is in complete contrast to *The Stars in Our Heaven* described above. Fiction is barred and we have instead an impressive collection of precise information about the universe we live in. First published in 1944, the book has now been revised and enlarged to deal with developments in the last five years and includes an informative note on radio astronomy in its infancy, when the first edition was published, but now a thriving science in its own right, together with many references to recent Cambridge work. The author tells us that he intended to provide a general outline of the most up-to-date knowledge of the heavenly bodies and to show methods employed by the astronomer to derive their distances, masses and temperatures.

The mathematics required for this purpose, he says, is elementary—about the standard attained on leaving school. Dr. Davidson provides convincing proof that this is true, and his discreet inclusion of simple mathematical formulae has added much interest to his work.

It is refreshing, too, to find such clarity of presentation. There is an abundance of good diagrams and pictures, an adequate index, and frequent and efficient use of cross-heads. A rough glance at the latter shows that the author, in his great knowledge, has not forgotten the days when many things mystified him which he must now take for granted. L.B.

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